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# The Long-Term International Transmission Grid of West Africa with Low and High Demand Electricity Growth Rates

## ~ A WAPP Training Report ~

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## SUMMARY

The March 2001 Modeling Report, submitted to ECOWAS in Dakar, Senegal, provided demonstration runs of the West Africa Power Pool (WAPP) model with free trade regimes having total expansion costs of $16.5 billion [1]. With severe constraints on electricity trade the increased total costs to the region (capital and operational) could be as high as an extra 27%. Capital expenditure for the building and expansion of the proposed and existing international transmission lines was shown to be the most attractive investment for the WAPP. For the 20 year long-term planning horizon the demonstration results indicated that there should approximately be a 900% increase in the load carrying capability of the international lines (nearly 9000MW added) in order to meet the expected growth in electricity demand, and maintain minimum costs for the region.

The March report satisfied the first modeling request of the ECOWAS Technical Working Group (TWG) which met in Accra, Ghana, in November 2000, (ie. the effect of the autonomy factor on WAPP energy trade policy). The second modeling request from the TWG was to demonstrate the sensitivity of electricity demand growth on WAPP development policies. This current report fulfills this second requirement of the Ghana meeting. While the earlier report is based upon a WAPP expected electricity growth rate this report considers a low demand growth rate scenario and a high demand growth scenario.

| Scenario for 2001-2020 | Total International Transmission Expansion (MW) | Increase on Existing 2001 International Transmission (%) | Total ECOWAS Regional Costs ($ Billions) |
|---|---|---|---|
| Low Demand Growth | 3,933 | 392 | 11.98 |
| Expected Demand Growth | 8,974 | 894 | 16.52 |
| High Demand Growth | 14,145 | 1,410 | 28.19 |

With a low demand growth scenario (25% below expected demand growth) there is a 392% increase in the region's international transmission load carrying capability. This reflects an approximate fourfold increase in the region's total electricity trade with a total cost to the ECOWAS region of nearly $12 billion for the period 2001 to 2020.

In the high demand growth scenario (25% above expected demand growth) there is a massive 1,410% increase in the region's total transmission load carrying capability. As the growth rates increase then so too there is a much greater need for more electricity trade and extra transmission capacity to transmit the electricity for keeping aggregate regional costs to a minimum. The total cost to the region under a high growth scenario exceeds $28 billion.

These two interim WAPP modeling reports, for 2000 to 2001, focus attention on the transmission capacity expansions across the ECOWAS region. These modeling reports provide support to the ECOWAS initiative for the development of a regional grid. The 2001 to 2002 WAPP modeling work is to concentrate on regional training. At some later stage it is anticipated that a similar high profile attention be given to modeling the generation expansion plans for across the region. With further validation of the ECOWAS electricity data bank this further stage of the WAPP modeling activity will be about ready to take place.

## 1. Overview of Total Regional Costs for Low, Expected & High Demand Growth Rates

This interim report #2, for 2000 to 2001, uses the WAPP demonstration model to indicate the great significance of reliable electricity demand growth rates in future ECOWAS planning. Attention to WAPP demand forecasting is so significant it merits a project unto itself. Having said this it can be seen that by decreasing the growth rates by 25% there will be a 56% decrease, compared with the expected demand growth, in total regional transmission capacity (Table 1).

Table 1

| | Total Cost ($ billion) | Total Existing Transmission Expansion (MW) | Total New Transmission Expansion (MW) | Total Transmission Expansion (MW) | Change from Base Case Expected Growth |
|---|---|---|---|---|---|
| (a) Low Growth | 11.98 | 2,009 | 1,924 | 3,933 | 56% decrease |
| (b) Expected Growth | 16.52 | 5,134 | 3,840 | 8,974 | 0 |
| (a) High Growth | 28.19 | 8,181 | 5,964 | 14,145 | 58% increase |

Total existing international transmission lines capacity in 2001 is 1003MW.

A 25% increase in regional demand growth rates produces a 58% increase in total regional transmission capacity, compared with expected demand growth. There is a 135% increase in total regional costs when comparing the low growth scenario with the high growth scenario (Table 2; $11.98 billion compared with $28.19 billion).

Table 2 Costs for High & Low Demand Growth Rates of ECOWAS Transmission & Generation Capacity Expansions for 2001 to 2020

| All costs in $ millions PV | LOW GROWTH | HIGH GROWTH | % INCREASE |
|---|---|---|---|
| Total Regional Costs | 11,980 | 28,194 | 135 |
| (a) Capital Cost | | | |
| Old Thermal | 34 | 193 | 468 |
| Combined Cycle | 2,267 | 7,472 | 230 |
| Combustion Turbine | 13 | 34 | 162 |
| Old Hydropower | 19 | 67 | 253 |
| New Hydropower | 1,259 | 2,072 | 65 |
| New Transmission Lines | 112 | 361 | 222 |
| Old Transmission Lines | 69 | 197 | 186 |
| Total capital costs (PV) | 3,775 | 10,399 | 175 |
| (b) Fuel | 6,558 | 13,907 | 112 |
| (c) Fixed O & M | 190 | 270 | 42 |
| (d) Variable O & M | 1,112 | 2,061 | 85 |
| (e) Water | 127 | 133 | 5 |
| (f) Distributed Generation | 16 | 152 | 850 |

In all demand growth scenarios it can be seen how the existing 2001 international lines in West Africa will have continuous strategic importance in a regional West Africa electricity trade market. The expansions in capacities on the existing lines exceed expansions on the proposed new international lines for the region, in all three growth

scenarios (Table 1). In the low growth scenario the total cost for 2001 to 2020 on new international lines in $112 million and in the high growth scenario it increases to $361 million (222% increase; Table 2).

The cost of expanding capacity on the existing lines and for the low growth scenario for 2001 to 2020 is estimated at $69 million. This amount increases by 186% to $197 million in a high growth scenario (Table 2). These relatively small investments in the region provide the framework for making large cost savings in a future fully integrated West Africa power pool.

## 2. International Transmission Lines & the ECOWAS MASTER PLAN

The transmission lines included in the demonstration model (Table 3) closely agree with the ECOWAS Master Plan. The WAPP model is for the analysis of international trade and so only includes the existing and proposed international transmission lines.

Table 3. WAPP International Transmission Lines
(ECOWAS Data Set #4, August 2000)

| *Line Name* | *Line Type** | *Load Carrying Capability (MW)* | *Line Voltage (kV)* | *Route Length (km)* | *Fixed Capital Cost ($10^6$)* | *Variable Expansion Cost ($10^6$/MW)* |
|---|---|---|---|---|---|---|
| (1) Ben-Tog | OT | 150 | 161 | 183 | | 0.100 |
| (2) BFa-ICo | OT | 200 | 225 | 150 | | 0.101 |
| (3) Gha-Tog | OT | 256 | 161 | 129 | | 0.102 |
| (4) Gha-ICO | OT | 327 | 225 | 220 | | 0.101 |
| (5) Mal-Sen + | OT | 150 | 225 | 821 | | 0.108 |
| (6) Ngr-Nga | OT | 70 | 132 | 264 | | 0.103 |
| | | | | | | |
| (7) Ben-Nga | NT | 560 | 330 | 16 | 20.0 | 0.100 |
| (8) Gam-Sen | NT | 20 | 225 | 110 | 27.83 | 0.273 |
| (9) Gui-Sen | NT | 150 | | | 19.27 | 0.112 |
| (10) Gui-ICo | NT | 150 | 225 | 450 | 65.22 | 0.102 |
| (11) Gui-SLe | NT | 80 | 110 | 93 | 13.48 | 0.103 |
| (12) Gui-GBi | NT | 150 | 225 | 123 | 17.82 | 0.104 |
| (13) Gui-Mal | NT | 90 | 225 | 368 | 53.33 | 0.105 |
| (14) Lib-Gui | NT | 80 | | | 13.48 | 0.106 |
| (15) Lib-SLe | NT | 80 | | | 13.48 | 0.107 |
| (16) Mal-ICo | NT | 100 | 225 | 616 | 88.18 | 0.109 |
| (17) BFa-Gha | NT | 30 | 225 | 1160 | 7.5 | 0.400 |

Note:
* OT = Old/existing international transmission line
* NT = New/proposed international transmission line
** = Line capacity in 2020 assuming there has been optimal expansion with free trade policies & expected growth
+ = Mal-Sen Line – all decisions have been taken – assumed to exist in 2001/2002

Table 4. International Transmission Lines in the ECOWAS Master Plan

| *Phase I* | | *Phase II* | |
|---|---|---|---|
| ** Ikeja/Sakete, | Nga-Ben | ** Conakry/Bumbuna, | Gui-SLe |
| Sakete/Tema, | Tog-Gha | * Conakry/Fomi, | Gui-Gui |
| Katsina/Maradi/Zinder, | Nga-Ngr | ** Fomi/Selingue, | Gui-Mal |
| ** Bolgatanga/Ouagadougou, | Gha-BFa | ** Fomi-Man, | Gui-ICo |
| Bobo-Dioulasso/Ferkessedougou, | BFa-ICo | * Bissau/Saltinho, | GBi-GBi |
| ** Ferkessedougou/Ouelessebougou, | ICo-Mal | * Dakar/Ziguinchor, | Sen-Sen |
| * Bamako/Manantali, | Mal-Mal | ** Banjul/Ziguinchor, | Gam-Sen |
| Manantali/Dagana, | Mal-Sen | Ziguinchor/Bissau, | Sen-GBi |
| Dagana/Nouakchott, | Sen-Mau | Maiduguri/Diffa, | Nga-Ngr |
| * Dagana/Sakal, | Sen-Sen | * Bobo-Dioulasso/Ouagadougou, | BFa-BFa |
| * Freetown/Bumbuna, | SLe-SLe | Man/Monrovia, | ICo-Lib |
| | | ** Odienne/Selingue, | ICo-Mal |

Notes: Table supplied at Dakar ECOWAS Meeting, March 20-22, 2001
* These lines are national lines & not international – therefore not in the WAPP regional model
** New international transmission lines

All of the transmission lines indicated with the " ** " are listed in both the ECOWAS Master Plan as well as in the ECOWAS Data Set#4, Table 3. The lines in Table 3 are the ones currently in the WAPP regional model.

The lines indicated with the " * " in Table 4 are all national lines, proposed to be built within a national boundary, and technically are not included in the WAPP regional model. This is because the existing purpose of the model is to assess international electricity trade. With modifications and improvements however to the ECOWAS regional model this national functional requirement could be added.

The proposed international lines connecting Liberia and Guinea Bissau into the regional grid need further clarification. The data in the ECOWAS Data Set #4, which is supplied by the ECOWAS electricity utilities, does not fully agree with the lines listed in the ECOWAS Master Plan. This inconsistency can be readily corrected and new lines added to future WAPP models.

## 3. Transmission Line Capacity Expansions With Low and High Demand Growth Rates

Figure 2 and Tables 7 and 8 give a detailed summary of international transmission line capacity expansions for 2001 to 2020 under a low electricity demand growth scenario. (The line expansions reported in the Dakar March Report [1] with expected growth are shown in Figure 1 and Tables 5 and 6). The same trend is shown in Figure 2, for the low demand growth scenario, with major expansions from Nigeria to Ghana and significant electricity trade. The three links Nga-Ben, Ben-Tog, and Tog-Gha show the expansions to be less than half of the size with low growth compared to those demonstrated with expected growth. Within the Zone B for low growth the two links ICo-Gui and Gui-Sen are still the two most important regional links within the zone. These values are significantly reduced compared with the expected growth capacities, but not so significantly as in the case of the expansions on the existing lines for the Zone A coastal links.

As shown in Table 1 there is a 56% reduction (3,933 MW from 8,974 MW) in total regional MW transmission capacity with the low growth scenario, compared with the expected growth. Total expansion on the existing lines reduced from 5,134 MW (expected growth) to 2,009 MW (low growth). With the proposed new lines for the low growth scenario the reduction goes from 3,840 MW to 1,924 MW.

Comparing the low and expected growth scenarios there is very little change in the capacity expansions for Sen-Gam and Gui-Lib. The capacities of Mal-Gui and Mal-ICo reverse their orders of importance with these two growth scenarios.

There is a 58% increase in total international transmission capacity (14,145 MW from 8,974 MW) within the region when there is a high demand growth (Table 1). Total expansion on the existing lines increased from 5,134 MW (expected growth) to 8,181 MW (high growth). With the proposed new lines for the high growth scenario the increase goes from 3,840 MW to 5,964 MW.

In the high growth scenario compared with the expected growth there is a similar change of capacity in the three links between Nigeria and Ghana as in the comparison between the low and expected scenario. The two links, Gha-ICo and ICo-Gui become much more important in the high growth scenario. The expansion on the Gha-ICo link nearly triples in capacity for the high growth to 2,622MW compared with 943 MW in the expected growth (being only 224 MW in the low growth). The ICo-Gui link more than triples in capacity in the high growth scenario to 1,410 MW compared with 442 MW in the expected growth scenario (being only 269 MW in the low growth).

The Gha-ICo link expands an enormous 1170% when comparing the low growth expansion with the high growth expansion, (224 MW compared with 2,622 MW). The ICo-Gui link, when comparing the low growth to the high, expands 524% (269 MW compared with 1,410 MW). Cote D'Ivoire becomes a major importer from Ghana towards the end of the 20 year planning horizon.

While having excess capacity at the start of the 20 year planning horizon Cote D'Ivoire has no generation capacity expansion plan and so eventually becomes a major importer of power from Ghana. In the high growth scenario Cote D'Ivoire is also wheeling large amounts of MW from Ghana to Guinea.

The list of values for the electricity demand growth rates, in both the low and high growth scenarios for each country, are given in Appendix I.

**Table 5. Expected Demand Growth & Expansion of Existing Transmission Lines (MW)**

| Transmission Line | Period 1 Years 2001/2 | 2 2003/4 | 3 2005/6 | 4 2007/8 | 5 2009/10 | 6 2011/12 | 7 2013/14 | 8 2015/16 | 9 2017/18 | 10 2019/20 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Ben-Tog | | 370 | | | | 70 | 251 | 390 | 488 | 822 | 2,391 |
| (3) Gha-Tog | | 342 | | | | | 165 | 366 | 455 | 727 | 2,055 |
| (4) Gha-ICO | | 112 | 216 | 51 | | | | | | 237 | 616 |
| (6) Ngr-Nga | | | | | | | 6 | 19 | 22 | 25 | 72 |

Total Regional Expansion on existing lines is 5,134MW

**Table 6. Expected Demand Growth & Expansion of Existing Transmission Lines (MW)**

| New Transmission Line | Period 1 Years 2001/2 | 2 2003/4 | 3 2005/6 | 4 2007/8 | 5 2009/10 | 6 2011/12 | 7 2013/14 | 8 2015/16 | 9 2017/18 | 10 2019/20 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (7) Ben-Nga | | 496 | | 64 | | 75 | 268 | 407 | 519 | 938 | 2,767 |
| (8) Gam-Sen | | 21 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 31 |
| (9) Gui-Sen | | 147 | 21 | 25 | 23 | 20 | 25 | 30 | 34 | 40 | 365 |
| (10) Gui-ICo | | 336 | | 106 | | | | | | | 442 |
| (11) Gui-SLe | | 13 | | | 30 | 10 | | | | | 53 |
| (12) Gui-GBi | | 6 | 1 | 1 | 1 | 2 | 2 | 2 | | | 15 |
| (13) Gui-Mal | | | | | 1 | 34 | | | | | 35 |
| (14) Lib-Gui | | 3 | | | 17 | | | | | | 20 |
| (15) Lib-SLe | | | | | 3 | | | | | | 3 |
| (16) Mal-ICo | | 4 | 7 | 94 | 1 | | | | | | 106 |

Total Regional Expansion with new lines is 3,840MW

Figure1. Total ECOWAS International Transmission Capacities in 2020
With Expected Electricity Demand Growth & Free Trade Expansion (MW)

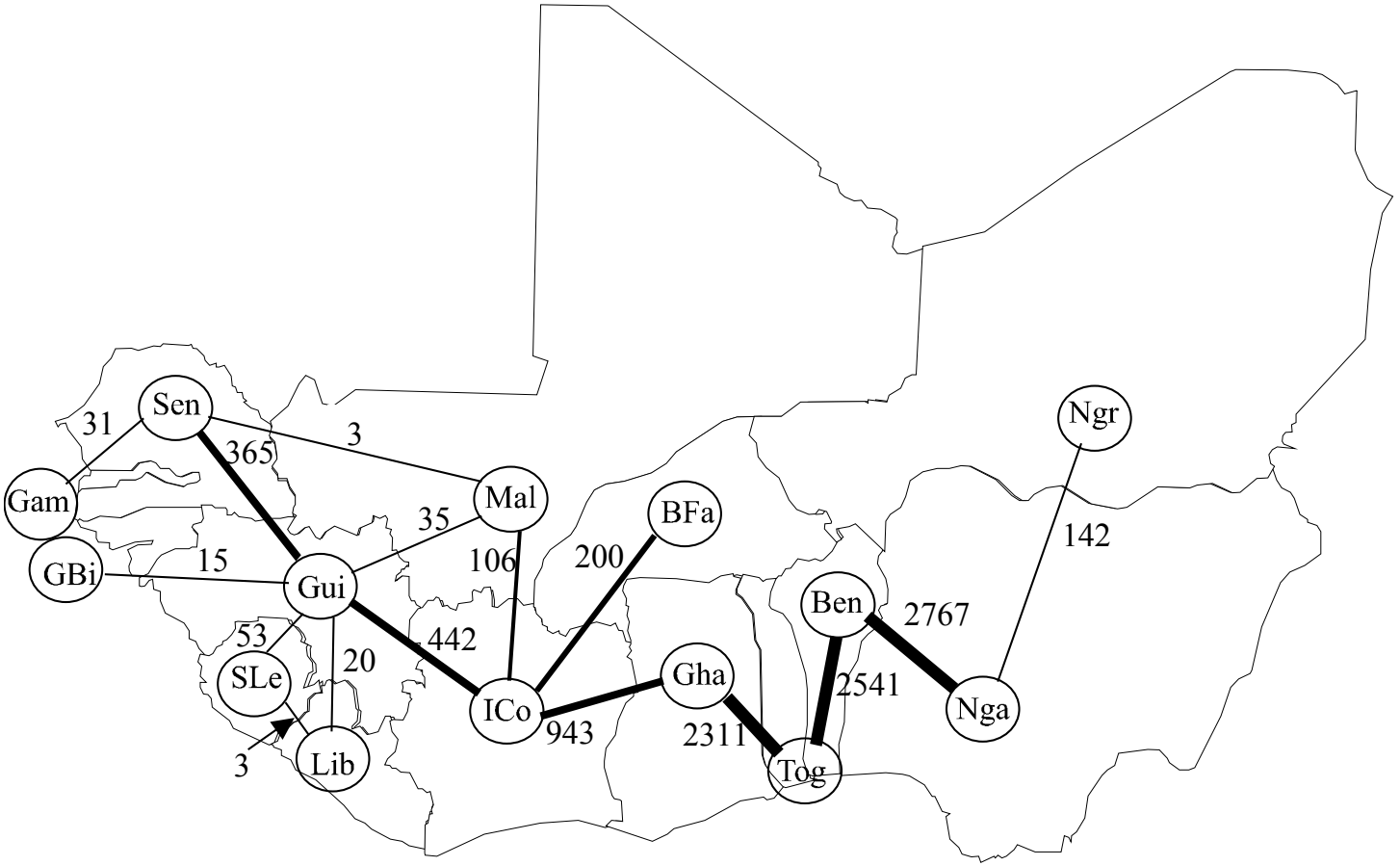


**Table 7. Low Demand Growth & Expansion of Existing Transmission Lines (MW)**

| Transmission Line | Period 1 Years 2001/2 | 2 2003/4 | 3 2005/6 | 4 2007/8 | 5 2009/10 | 6 2011/12 | 7 2013/14 | 8 2015/16 | 9 2017/18 | 10 2019/20 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Ben-Tog | | 375 | 8 | | | | 49 | 206 | 159 | 188 | 985 |
| (3) Gha-Tog | | 339 | 17 | | | | | 105 | 148 | 176 | 785 |
| (4) Gha-ICO | | | 157 | 67 | | | | | | | 224 |
| (6) Ngr-Nga | | | | | | | | | 2 | 13 | 15 |

Total Regional Expansion on existing lines is 2, 009MW

**Table 8. Low Demand Growth & Expansion of Proposed Transmission Lines (MW)**

| New Transmission Line | Period 1 Years 2001/2 | 2 2003/4 | 3 2005/6 | 4 2007/8 | 5 2009/10 | 6 2011/12 | 7 2013/14 | 8 2015/16 | 9 2017/18 | 10 2019/20 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (7) Ben-Nga | | 508 | | 52 | | | 48 | 216 | 161 | 190 | 1,175 |
| (8) Gam-Sen | | 20 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 27 |
| (9) Gui-Sen | | 143 | 12 | 14 | 13 | 15 | 22 | 21 | 23 | 26 | 289 |
| (10) Gui-ICo | | 269 | | | | | | | | | 269 |
| (11) Gui-SLe | | 3 | 1 | | 3 | | | | | | 7 |
| (12) Gui-GBi | | 6 | | | | | 1 | 1 | 1 | 1 | 10 |
| (13) Gui-Mal | | | 8 | | 57 | 28 | | | | | 93 |
| (14) Lib-Gui | | | | 20 | | | | | | | 20 |
| (15) Lib-SLe | | 3 | | | 1 | | | | | 8 | 12 |
| (16) Mal-ICo | | 22 | | | | | | | | | 22 |

Total Regional Expansion with new lines is 1,924MW

Figure 2. Total ECOWAS International Transmission Capacities in 2020
With Low Electricity Demand Growth & Free Trade Expansion (MW)

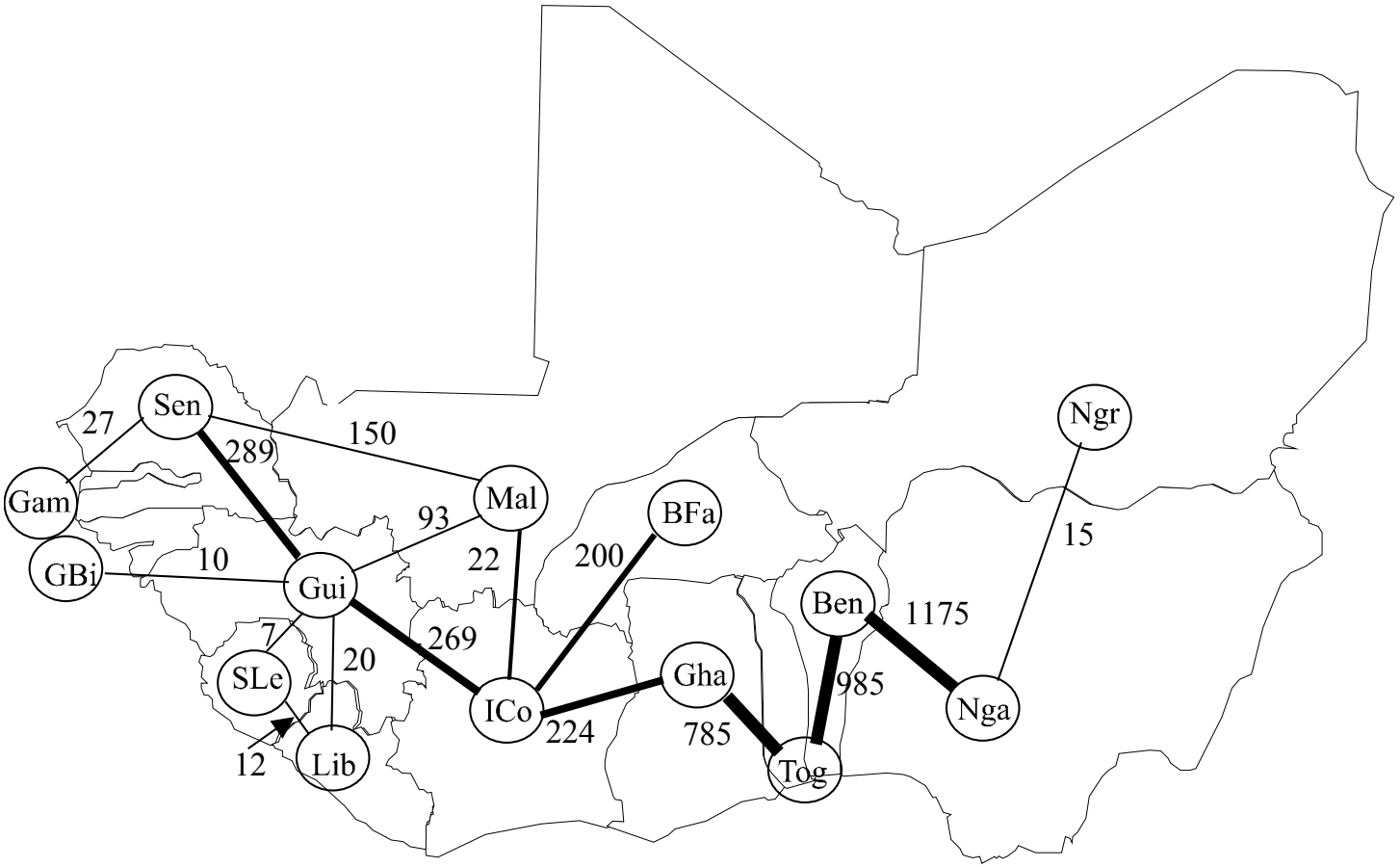


**Table 9. High Demand Growth & Expansion of Existing Transmission Lines (MW)**

| Transmission Line | Period 1 Years 2001/2 | 2 2003/4 | 3 2005/6 | 4 2007/8 | 5 2009/10 | 6 2011/12 | 7 2013/14 | 8 2015/16 | 9 2017/18 | 10 2019/20 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Ben-Tog | | 286 | 70 | 146 | 482 | 655 | 849 | 639 | 113 | 30 | 3270 |
| (3) Gha-Tog | | 284 | | 79 | 454 | 617 | | 595 | 133 | 23 | 2185 |
| (4) Gha-ICO | | 68 | | | 252 | 382 | 446 | 503 | 971 | | 2622 |
| (6) Ngr-Nga | | | | | | 19 | 27 | 31 | 27 | | 104 |

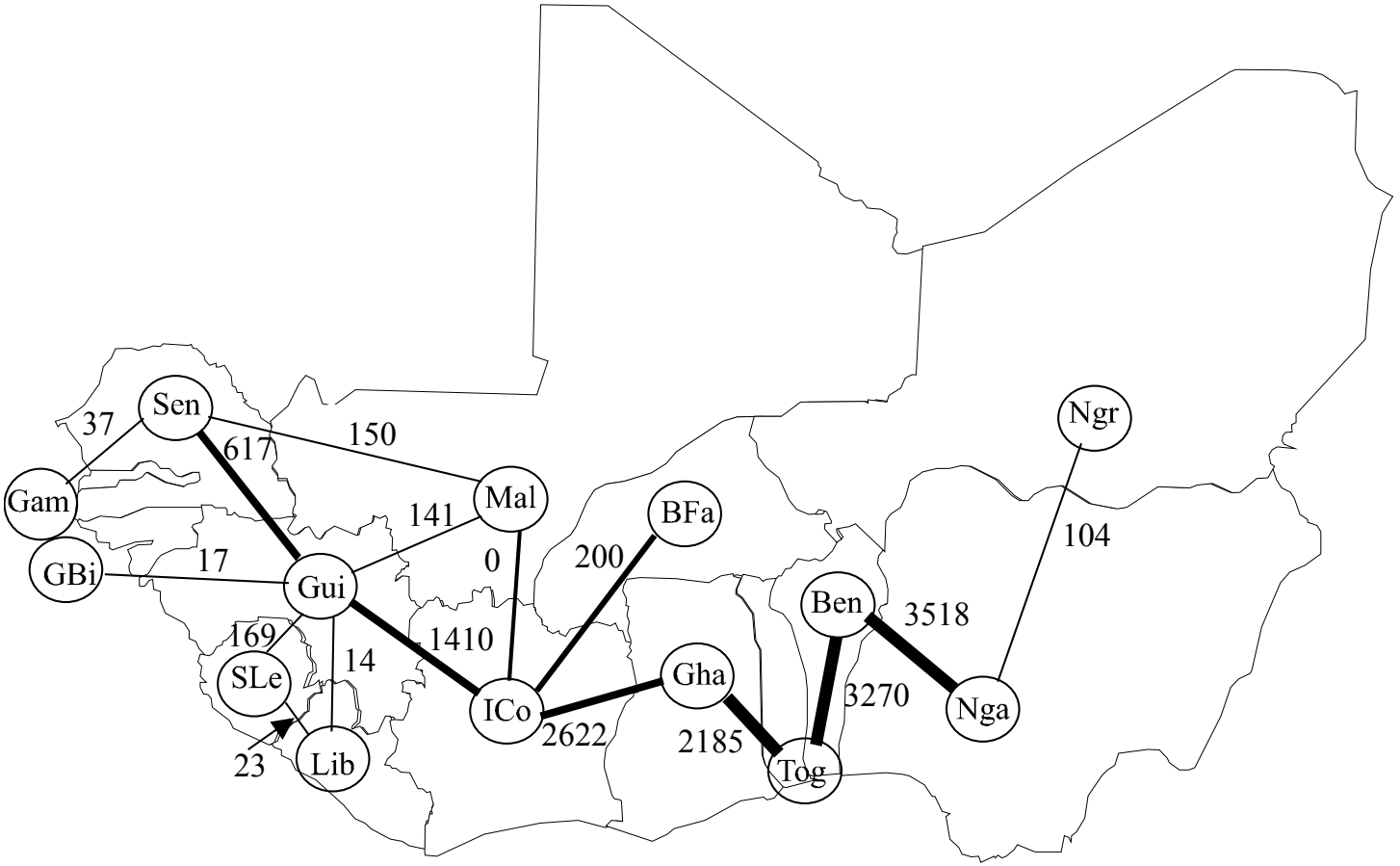
Total Regional Expansion on existing lines is 8,181MW

**Table 10. High Demand Growth & Expansion of Proposed Transmission Lines (MW)**

| New Transmission Line | Period 1 Years 2001/2 | 2 2003/4 | 3 2005/6 | 4 2007/8 | 5 2009/10 | 6 2011/12 | 7 2013/14 | 8 2015/16 | 9 2017/18 | 10 2019/20 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (7) Ben-Nga | | 407 | 153 | 153 | 506 | 685 | 955 | 659 | | | 3,518 |
| (8) Gam-Sen | | 22 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 37 |
| (9) Gui-Sen | | 161 | 26 | 32 | 34 | 46 | 53 | 104 | 162 | 0 | 617 |
| (10) Gui-ICo | | 314 | 76 | | 219 | 255 | 111 | 60 | 375 | | 1,410 |
| (11) Gui-SLe | | 23 | | | 16 | 33 | 39 | 35 | 23 | | 169 |
| (12) Gui-GBi | | 6 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 17 |
| (13) Gui-Mal | | 4 | 106 | 16 | | | | | | 15 | 141 |
| (14) Lib-Gui | | 1 | 3 | | | | | | 8 | 2 | 14 |
| (15) Lib-SLe | | 4 | 19 | | | | | | | | 23 |

Total Regional Expansion with new lines is 5,964MW

Figure 3. Total ECOWAS International Transmission Capacities in 2020
With High Electricity Demand Growth & Free Trade Expansion (MW)



## 4. Electricity Energy Trade in the High and Low Demand Growth Scenarios for Guinea & Ghana

The electricity energy trade in these two case studies is determined by the levels of demand and supply for each time period. The generation capacities that are available at the end of the 2001-2020 planning horizon, under the low and high demand scenarios, are summarized below at the start of Sections 4.1 and 4.3.

### 4.1 **Low Growth & Guinea's Electricity Energy Trade for 2001 to 2020**

Guinea Low Growth Scenario:
65 MW old thermal generation
127 MW old hydropower generation
840 MW new hydropower generation

Guinea High Growth Scenario:
85 MW old thermal generation
127 MW old hydropower generation
1,732 MW new hydropower generation

Electrical energy imports into Guinea (GWh/Year)

| Period: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| From: ICo | 0 | 0 | 0 | 0.1 | 0 | 0 | 0 | 2.3 | 0.1 | 8.4 |
| From: GBi | 0 | 1.8 | 1.1 | 0.5 | 0.2 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| From: Lib | 0 | 0.9 | 0.2 | 178.4 | 172.3 | 164.1 | 155.1 | 159.5 | 132.4 | 61.2 |
| From: Mal | 0 | 0 | 70.4 | 70.4 | 536.9 | 765.1 | 763.6 | 762.1 | 760.6 | 759.0 |
| From: Sen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| From: SLe | 0 | 0 | 1.5 | 30.0 | 4.5 | 2.4 | 0 | 0.7 | 0 | 0 |
| Total: | 0 | 2.8 | 73.4 | 279.5 | 713.9 | 931.9 | 918.9 | 924.7 | 893.2 | 828.9 |

Electrical energy exports from Guinea (GWh/Year)

| To: ICo | 0 | 2189 | 1528 | 1025 | 1265 | 1213 | 1329 | 1105 | 1284 | 1047 |
|---|---|---|---|---|---|---|---|---|---|---|
| To: GBi | 0 | 19 | 24 | 29 | 33 | 38 | 42 | 45 | 47 | 51 |
| To: Lib | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| To: Mal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| To: Sen | 0 | 1036 | 1127 | 1232 | 1326 | 1438 | 1573 | 1720 | 1880 | 2060 |
| To: SLe | 0 | 22 | 29 | 0 | 0 | 56 | 21 | 0 | 47 | 6 |
| Total: | 0 | 3268 | 2711 | 2286 | 2625 | 2746 | 2968 | 2871 | 3259 | 3165 |

### 4.2 **High Growth & Guinea's Electricity Energy Trade for 2001 to 2020**

Electrical energy imports into Guinea (GWh/Year)

| Period: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| From: ICo | 0 | 0 | 0 | 1099 | 2007 | 2995 | 4105 | 5227 | 6474 | 7397 |
| From: GBi | 0 | 3.0 | 1.6 | 0.4 | 0.1 | 0.1 | 0.1 | 0.2 | 0 | 0 |
| From: Lib | 0 | 0 | 31.0 | 36.0 | 18.0 | 11.0 | 5.0 | 0.6 | 0 | 0 |
| From: Mal | 0 | 37 | 901 | 744 | 572 | 419 | 261 | 108 | 0 | 0 |
| From: Sen | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| From: SLe | 0 | 0 | 0 | 21 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total: | 0 | 40 | 934 | 1900 | 2598 | 3426 | 4371 | 5336 | 6474 | 7397 |

Electrical energy exports from Guinea (GWh/Year)

| To: ICo | 0 | 2513 | 2288 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|
| To: GBi | 0 | 17 | 25 | 34 | 45 | 51 | 57 | 64 | 79 | 97 |
| To: Lib | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| To: Mal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 60 | 286 |
| To: Sen | 0 | 1170 | 1354 | 1577 | 1819 | 2125 | 2506 | 2961 | 3480 | 4098 |
| To: SLe | 0 | 199 | 148 | 0 | 103 | 262 | 448 | 565 | 709 | 878 |
| Total: | 0 | 3904 | 3817 | 1611 | 1967 | 2438 | 3012 | 3591 | 4327 | 5359 |

## 4.3 **Low Growth & Ghana's Electricity Energy Trade for 2001 to 2020**

Ghana Low Growth Scenario:
550 MW old thermal generation
330 MW combined cycle generation
1,222MW old hydropower generation
157 MW new hydropower generation

Ghana High Growth Scenario:
550 MW old thermal generation
2,310 MW combined cycle generation
1,222 MW old hydropower generation
728 MW new hydropower generation

Electrical energy imports into Ghana (GWh/Year)

| Period: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| From: ICo | 361 | 47 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| From: Tog | 0 | 582 | 2224 | 3423 | 3369 | 3303 | 3586 | 5069 | 6152 | 7439 |

Electrical energy exports from Ghana (GWh/Year)

| To: ICo | 0 | 211 | 1084 | 1838 | 2018 | 2239 | 2506 | 3173 | 3507 | 3999 |
|---|---|---|---|---|---|---|---|---|---|---|
| To: Tog | 604 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## 4.4 **High Growth & Ghana's Electricity Energy Trade for 2001 to 2020**

Electrical energy imports into Ghana (GWh/Year)

| Period: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| From: ICo | 588 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| From: Tog | 0 | 1412 | 3382 | 4388 | 7946 | 12800 | 18800 | 22500 | 23800 | 23500 |
| Total: | 588 | 1412 | 3382 | 4388 | 7946 | 12800 | 18800 | 22500 | 23800 | 23500 |

Electrical energy exports from Ghana (GWh/Year)

| To: ICo | 0 | 296 | 1098 | 3192 | 5320 | 8525 | 10900 | 13400 | 16200 | 19100 |
|---|---|---|---|---|---|---|---|---|---|---|
| To: Tog | 622 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total: | 622 | 296 | 1098 | 3192 | 5320 | 8525 | 10900 | 13400 | 16200 | 19100 |

With trade in and out of Guinea there is a switch in direction of trade with Cote D'Ivoire between the low and high demand scenarios as well as a significant increase in the level of trade with high growth (Figure 5). With low demand growth the trade flow is from Guinea to Cote D'Ivoire (using Guinea's low cost new hydropower stations). When it is high demand growth the trade flow is from Cote D'Ivoire into Guinea with wheeling of lower cost electricity across Cote D'Ivoire from Ghana and Nigeria (Figure 4).

Figure 4. Transmission Load Capabilities Between Cote D'Ivoire, Guinea & Ghana, with Low & High Demand Growth Scenarios (MW)

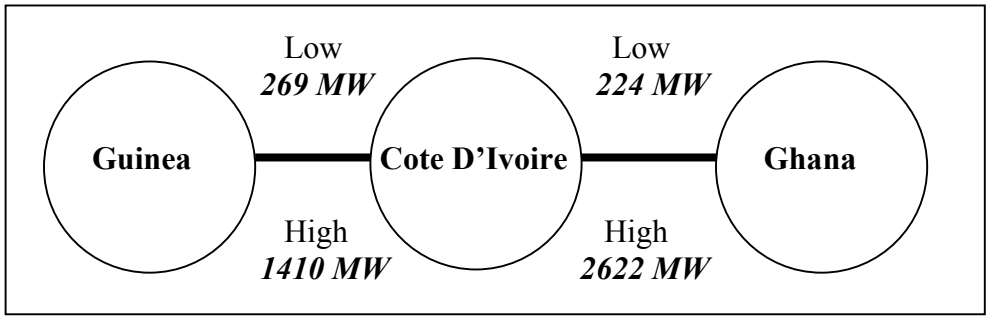


Figure 5. Electricity Energy Trade in 2019 & 2020 (GWh per year in period 10) Between Guinea & Other ECOWAS Countries For Low and High Electricity Demand Growth

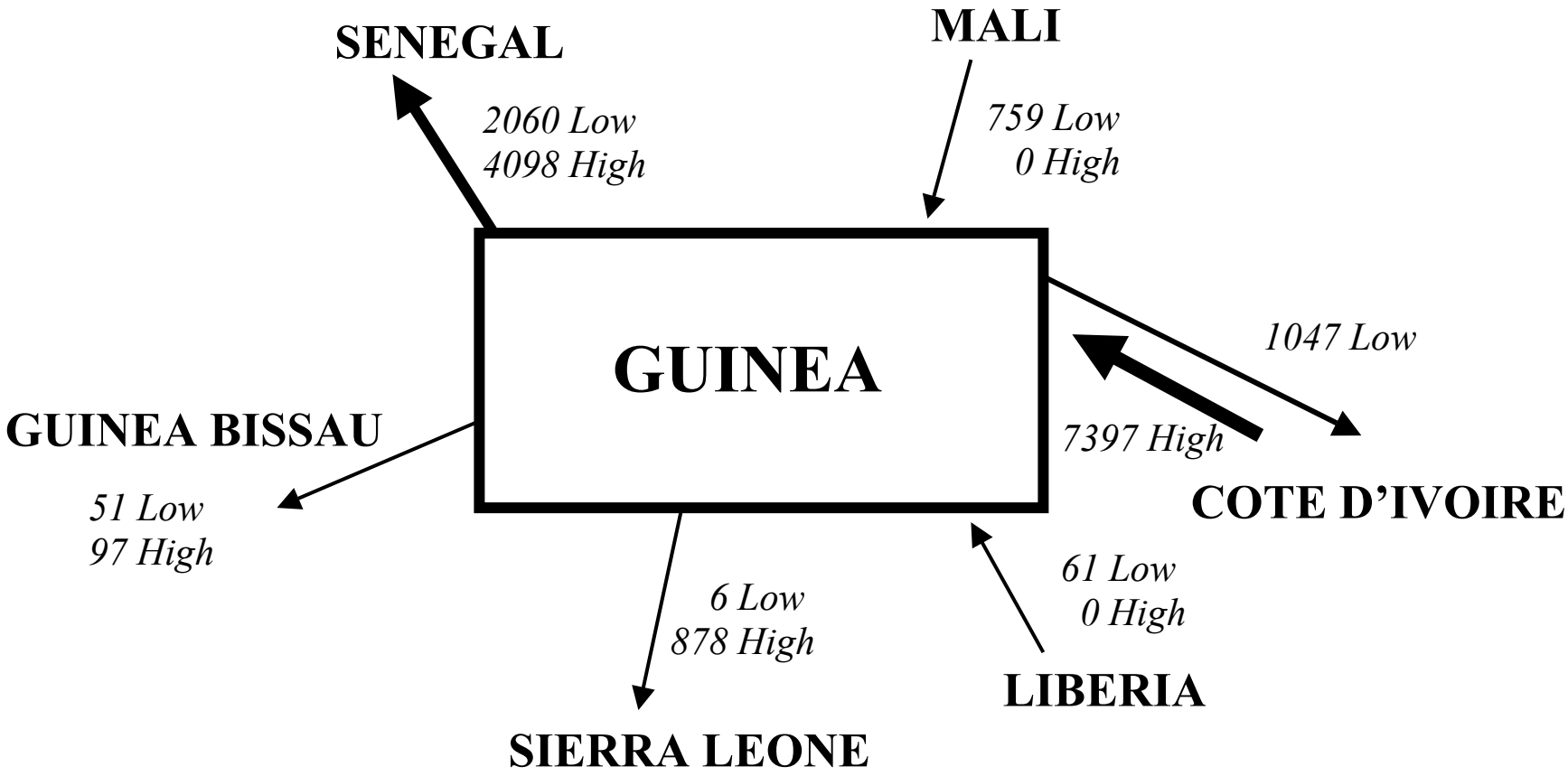
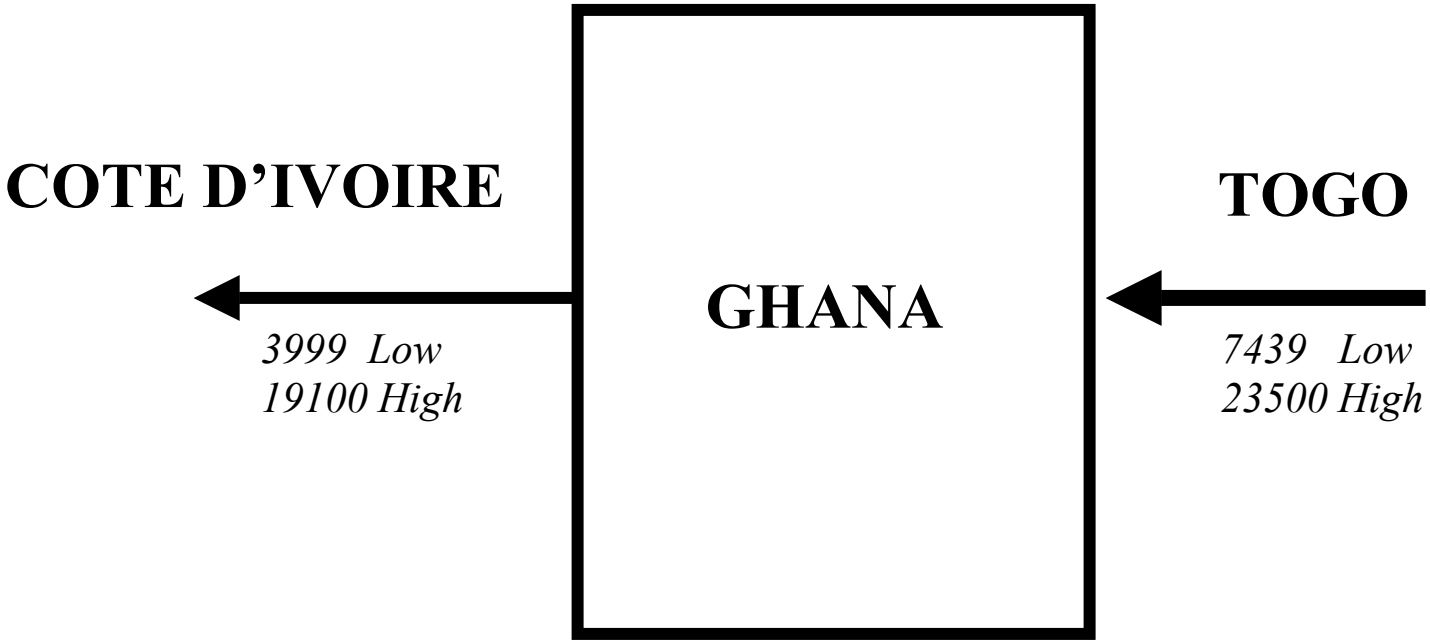


Figure 6. Electricity Energy Trade in 2019 & 2020 (GWh per year in period 10) Between Ghana & Other ECOWAS Countries For Low and High Electricity Demand Growth



There is an enormous change in the transmission capabilities between Cote D'Ivoire and Guinea and Ghana for the two growth scenarios. The maximum transmission capability between Cote D'Ivoire and Guinea for the low demand scenario is 269 MW but in the high demand scenario it is 1410 MW. Similarly with Ghana, for the low growth scenario the capability is 224 MW but with the high growth this increases to 2622 MW. The high demand growth scenario is so large that Nigeria's potential combined cycle generation must be employed to supply much of the ECOWAS region.

Throughout the 20 year planning horizon and in both the low and high demand growth scenarios Guinea supplies electricity to Guinea Bissau, Sierra Leone, and Senegal. The high growth scenario sees larger quantities of electricity being shipped for all three countries with much larger quantities going to Senegal (Figure 5). Liberia transmits a maximum of 20 MW of power to Guinea during the low growth scenario from its new hydropower station but this switches to Sierra Leone for the high growth scenario (Figure 5).

Figure 6 illustrates the electricity trade to and from Ghana. The proposed line between Ghana and Burkina Faso is never shown to be cost effective and so is not built in either the low or high demand growth scenario. The capital costs of all proposed new international transmission lines is a set of parameters that must be finally validated. Ghana has very significant increases in international lines with high growth (Figures 2 and 3). The Ghana to Togo link is 785 MW in the low scenario and is 2185 MW in the high scenario. The Ghana to Cote D'Ivoire link is 224 MW in the low scenario and is 2622 MW in the high scenario. These increases in load carrying capacity indicate the large increases in electricity trade. There is a fivefold in crease in electricity trade from Ghana to Togo and a threefold increase from Ghana to Cote D'Ivoire with the increase to a high demand growth (Figure 6). The complete national output files, together with explanatory notes, for Guinea and Ghana are listed in Appendix II.

## 5. ECOWAS Generation Capacity Expansions & Data Collection Needs

ECOWAS has given considerable attention to the proposed regional transmission expansions and the generation planning now requires its turn. The ECOWAS generation capacities for thermal and hydropower in 2000 are summarized in Figure 6.

The ECOWAS region, in 2000, has an equal mix of thermal generation and hydropower with 3,560 MW of total thermal power and 3,507 MW of total hydropower, giving a total generation reserve of 7,067 MW [2,3].

Table 11. Total ECOWAS Optimal Generation Expansions, 2001-2020

| (MW) | Low Growth | Expected Growth | High Growth |
|---|---|---|---|
| Total Generation Expansions | 16,915 | 29,934 | 58,623 |
| Combined Cycle | 14,969 | 28,219 | 52,810 |
| Turbine | 75 | 75 | 75 |
| New Hydropower | 1,374 | 1,484 | 3,371 |
| Old Hydropower | 150 | 156 | 560 |

Guinea, Ghana and Mali have more hydropower than thermal. Cote D'Ivoire and Senegal have more thermal power than hydropower [2,3].

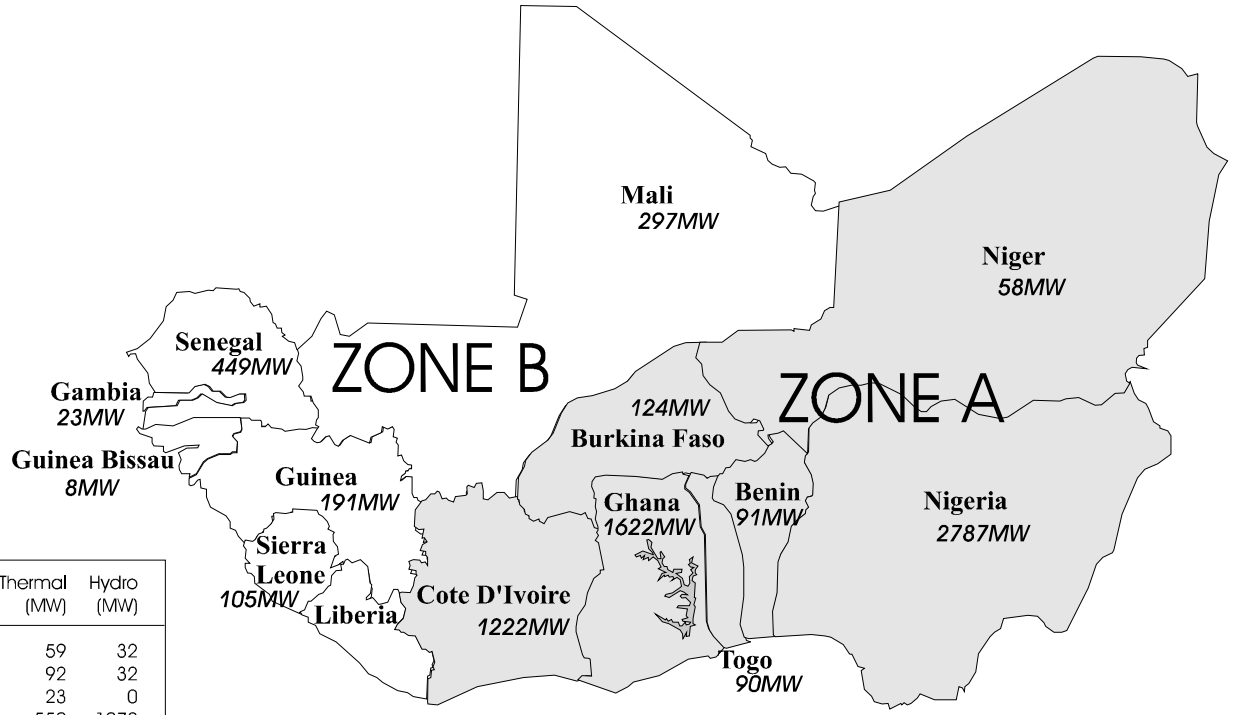
With a low growth in demand the region will need, by 2020, to have an extra 9,848 MW (16,915–7,067) of generation in order to meet the projected new peak demand (Table 11). If there is a high growth in demand then an extra 51,556 MW (58,623-7,067) will be required in order to meet the new level of peak demand in 2020 (Table 11).

The ECOWAS countries need to give more attention to the generation capacity expansion plans. To date a total of 3,247 MW is recorded for proposed new generation capacity, Table 12, [2,3]. There is a severe shortage of 6,601 MW (9,848-3,247) of planned generation capacity for the low demand growth scenario. The plans of Nigeria are not in the Data Set #4 on which these comparisons are made.

Table 12 Proposed New WAPP Generation Projects Recorded in ECOWAS Data Set #4 (February 2001)

| *Country & Project Name* | *MW Capacity* | *Technology* |
|---|---|---|
| Ben - Adjaralla East | 48.5 | HN |
| Ben - Dyodyonga South | 26.0 | HN |
| BFa - OuagaIII | 75.0 | PGNGT |
| BFa - Noumbiel | 60.0 | HN |
| Gha - Bui | 400.0 | HN |
| Gha - Juale | 87.0 | HN |
| Gha - Pwalugu | 48.0 | HN |
| Gha - Hemang | 93.0 | HN |
| Gha - Tema | 1980.0 | PGNCC |
| Gha - TICOtakoradi | 3330.0 | PGNCC |
| Gui – Tiopo | 120.0 | HN |
| Gui - ComplexeSouapitiKaleta | 975.0 | HN |
| Gui - Fomi | 90.0 | HN |
| Gui - FelloSounga | 82.0 | HN |
| Gui - Gaoual | 39.0 | HN |
| Gui - Morisanako | 100.0 | HN |
| Gui - Koukoutamba | 281.0 | HN |
| Gui - Guilde | 45.0 | HN |
| GBi - Saltinho *(page 92)* | 20.0 | HN |
| Lib - BushrodI (Refurbish) | 9.0 | PGNSC |
| Lib – BushrodII | 12.5 | PGNSC |
| Lib – LukeI | 48.0 | PGNSC |
| Lib – LukeII | 40.5 | PGNSC |
| Lib - Mitsubishi(Diesel) | 10.0 | PGNSC |
| Lib – MtCoffee | 64.0 | HN |
| Mal – Gouina | 104.0 | HN |
| Mal – Felou | 105.0 | HN |
| Mal - Petit Kenie | 56.0 | HN |
| Mal – Markala | 5.2 | HN |
| Ngr - Dyodyonga North | 26.0 | HN |
| Ngr – Gambou | 52.5 | HN |
| Ngr – Kandadji | 125.0 | HN |
| Total MW | 3247.2 | |

Figure 6. ECOWAS – Country MW Capacities & Power Pool Zones A & B




| Country | Thermal (MW) | Hydro (MW) |
|---|---|---|
| Ben | 59 | 32 |
| Bfa | 92 | 32 |
| Gam | 23 | 0 |
| Gha | 550 | 1072 |
| Gui | 65 | 126 |
| Gbi | 8 | 0 |
| Ico | 805 | 417 |
| Lib | 0 | 0 |
| Mal | 48 | 249 |
| Nga | 1370 | 1417 |
| Ngr | 58 | 0 |
| Sen | 383 | 66 |
| Sle | 41 | 64 |
| Tog | 58 | 32 |

Note: MW Capacities from ECOWAS Electricity Data Set #4, February 2001

Only the low demand growth scenario can be considered at this stage of the modeling because of inadequate generation data in the model.

The most significant generation data needs for the region are in Nigeria. In the ECOWAS Data Set #4 (February 2001) the stations in Nigeria are reported as shown at the top of Table 13, with model station numbers and having a total generating capacity of 3,308MW. Consultations, however, at the Dakar, March 2001 ECOWAS conference, indicate that by the end of 2002 that the Nigeria generation stations will be more realistically represented with all of the stations listed in Table 13 and therefore having a total generating capacity of 16,406 MW.

Table 13. Nigeria Generation Data from Dakar Conference, March 2001

| **Nigeria** *(Updated March 20, 2001)* | MW | Station Type | Model Station number |
|---|---|---|---|
| Afam | 558.0 | PGO | Nga Stat1 |
| Delta | 840.0 | PGO | Nga Stat2 |
| Lagos (Egbin) | 1320.0 | PGO | Nga Stat3 |
| Lagos Egbin Barges (Enron) | 270.0 | PGO | |
| Sapele (Ogorode) | 1020.0 | PGO | Nga Stat4 |
| Ijora | 40.0 | PGO | Nga Stat5 |
| Kainji *(page 128, Data Set #3)* | 760.0 | H | Nga Stat1 |
| Jebba *(page 129, Data Set #3)* | 578.4 | H | Nga Stat2 |
| Shiroro *(page 130, Data Set #3)* | 600.0 | H | Nga Stat3 |
| Kwale (CC) | 350.0 | PGO* | |
| Abuja EPP (Diesel) | 30.0 | PGO* | |
| Abuja Shell (CC) | 800.0 | PGO* | |
| ALSCON Smelter (CC) | 200.0 | PGO* | |
| AGIP (CC) | 500.0 | PGO* | |
| MOBIL (CC) | 340.0 | PGO* | |
| Onitsha (CC) | 2000.0 | PGO* | |
| Ajaokuta (CC) | 500.0 | PGO* | |
| Ompadec(GT) & Nafcon(GT) | 45.0 | PGO* | |
| Oji (coal) | 120.0 | PGO* | |
| Ikom (CC) | 2000.0 | PGO* | |
| Swede Power (CC) | 500.0 | PGO* | |
| Zungeru (CC) | 500.0 | PGO* | |
| Mambila (CC) | 2000.0 | PGO* | |
| Dankowa (CC) | 35.0 | PGO* | |
| Lokoja (CC) | 500.0 | PGO* | |
| TOTAL GENERATION | **16,406*** | | **3,308** |
| Note: * NEPA data = existing by late 2002<br>PGO = Existing thermal station<br>H = Existing hydropower station | | | |

For further progress in the modeling of the ECOWAS electricity policy it is essential that the Nigerian electricity generation plans with appropriately completed data sheets be validated. For the present model it is assumed that NEPA will have generation expansion of up to 50,000 MW from new combined cycle generation.

Table 14. Liberia Generation Data (Supplied May 8, 2001)

| **Liberia** *(Supplied May 8, 2001)* | MW | Station Type | Model Station number |
|---|---|---|---|
| Bushrod Skoda (Diesel) | 7.2 | PGO | Lib Stat1 |
| | | | |
| Bushrod Luke (Diesel) – awaiting refurbishment | 40.5 | PGN | Lib Stat1 |
| Bushrod Mitsubishi - awaiting refurbishment | 10.0 | PGN | Lib Stat2 |
| BushrodGasTurbine - awaiting refurbishment | 68.0 | PGN | Lib Stat3 |
| Mt Coffee (Hydro) - awaiting refurbishment | 64.0 | HN | Lib Stat1 |

Liberia's data in the model now needs updating with the supply of data sent to Purdue on May 8, 2001 (Table 14). The previous estimates, in Table 12, are not so very different to those just supplied. The major job in Liberia is one of refurbishment. The cost of refurbishment is now required.

In summary the data validation needs are:-

- Generation expansion plans for each country with the names of each new project
- Fixed & variable expansion costs for new generation capacity
- Fixed & variable expansion costs for existing & new transmission capacity
- Refurbishment costs of existing stations (treat as low-cost new stations)
- Outage rates for thermal & hydropower plants
- Fuel costs (all types) in US dollars
- Time constraints, At, Aft, Bef, and decommissioning times
- Line loss percentages
- Reserve margins for thermal & hydropower plants
- Hydropower minimum usage
- Escalation rates of fuel costs
- Decay rates of thermal stations
- Fixed & Variable O & M costs

Prior to further modeling work with the WAPP model each country will need to check the data in the ECOWAS Data Sets #3 and #4 [2,3]. This will ensure that each country is correctly represented within the regional electricity pool model.

## References

[1] F.T. Sparrow, Brian H. Bowen, "The West African Power Pool & Optimal Long-Term Planning of International Transmission with a Free Trade Electricity Policy", ECOWAS Power Pool Conference, Dakar, Senegal, March 20-22, 2001.

[2] West Africa Power Pool WAPP, DATA SET #4, ECOWAS & Purdue University, February 2001.

[3] West Africa Power Pool WAPP, DATA SET #3, ECOWAS & Purdue University, August 2000.

# Appendix I

## WAPP Demand Growth Rates Data

All values are obtained from the expected demand growth rates
(Low = Expected growth x 75%, High = Expected growth x 125%)

Country 1: **BENIN**

| Period – Years | Low % | Expected % | High % |
|---|---|---|---|
| 1 - 2001/2 | 9.3 | 12.4 | 15.4 |
| 2 - 2003/4 | 6.2 | 8.2 | 10.3 |
| 3 - 2005/6 | 5.7 | 7.6 | 9.4 |
| 4 - 2007/8 | 5.9 | 7.8 | 9.8 |
| 5 - 2009/10 | 6.1 | 8.2 | 10.2 |
| 6 – 2011/12 | 6.2 | 8.2 | 10.3 |
| 7 – 2013/14 | 6.3 | 8.4 | 10.5 |
| 8 - 2016/16 | 6.2 | 8.3 | 10.4 |
| 9 - 2017/18 | 6.1 | 8.1 | 10.1 |
| 10 - 2019/20 | 6.0 | 7.9 | 9.9 |

Country 2: **BURKINA FASO**

| Period – Years | Low % | Expected % | High % |
|---|---|---|---|
| 1 - 2001/2 | 7.4 | 9.8 | 12.3 |
| 2 - 2003/4 | 5.1 | 6.8 | 8.5 |
| 3 - 2005/6 | 6.9 | 8.3 | 11.6 |
| 4 - 2007/8 | 5.1 | 6.8 | 8.5 |
| 5 - 2009/10 | 5.2 | 6.9 | 8.7 |
| 6 - 2011/12 | 5.3 | 7.1 | 8.8 |
| 7 - 2013/14 | 5.4 | 7.2 | 9.0 |
| 8 - 2016/16 | 5.5 | 7.3 | 9.1 |
| 9 - 2017/18 | 5.4 | 7.3 | 9.1 |
| 10 - 2019/20 | 5.4 | 7.3 | 9.1 |

Country 3: **GAMBIA**

| Period – Years | Low % | Expected % | High % |
|---|---|---|---|
| 1 - 2001/2 | 7.5 | 10.0 | 12.5 |
| 2 - 2003/4 | 4.2 | 10.6 | 6.9 |
| 3 - 2005/6 | 1.9 | 2.5 | 3.1 |
| 4 - 2007/8 | 1.8 | 2.4 | 3.0 |
| 5 - 2009/10 | 1.7 | 2.3 | 2.8 |
| 6 - 2011/12 | 1.6 | 2.2 | 2.7 |
| 7 - 2013/14 | 1.6 | 2.1 | 2.6 |
| 8 - 2016/16 | 1.5 | 2.0 | 2.5 |
| 9 - 2017/18 | 0.0 | 0.0 | 0.0 |
| 10 - 2019/20 | 2.8 | 1.9 | 4.7 |

Country 4: **GHANA**

| Period – Years | Low % | Expected % | High % |
|---|---|---|---|
| 1 - 2001/2 | 4.8 | 6.5 | 8.1 |
| 2 - 2003/4 | 4.2 | 5.7 | 7.1 |
| 3 - 2005/6 | 5.3 | 7.1 | 8.8 |
| 4 - 2007/8 | 3.6 | 4.8 | 6.0 |
| 5 - 2009/10 | 3.6 | 4.9 | 6.1 |
| 6 - 2011/12 | 3.8 | 5.0 | 6.3 |
| 7 - 2013/14 | 3.8 | 5.1 | 6.3 |
| 8 - 2016/16 | 3.7 | 5.0 | 6.2 |
| 9 - 2017/18 | 3.7 | 4.9 | 6.1 |
| 10 - 2019/20 | 3.7 | 4.9 | 6.1 |

Country 5: **GUINEE BISSAU**

| Period – Years | Low % | Expected % | High % |
|---|---|---|---|
| 1 - 2001/2 | 3.8 | 5.1 | 6.4 |
| 2 - 2003/4 | 3.7 | 4.9 | 6.1 |
| 3 - 2005/6 | 3.8 | 5.0 | 6.3 |
| 4 - 2007/8 | 3.4 | 4.6 | 5.7 |
| 5 - 2009/10 | 3.3 | 4.4 | 5.5 |
| 6 - 2011/12 | 3.6 | 4.9 | 6.1 |
| 7 - 2013/14 | 3.5 | 4.6 | 5.8 |
| 8 - 2016/16 | 3.7 | 4.9 | 6.1 |
| 9 - 2017/18 | 3.6 | 4.8 | 5.9 |
| 10 - 2019/20 | 3.7 | 4.9 | 6.1 |

Country 6: **GUINEE**

| Period – Years | Low % | Expected % | High % |
|---|---|---|---|
| 1 - 2001/2 | 3.1 | 4.1 | 5.1 |
| 2 - 2003/4 | 2.9 | 3.9 | 4.9 |
| 3 - 2005/6 | 71.2 | 94.9 | 118.6 |
| 4 - 2007/8 | 1.0 | 1.4 | 1.7 |
| 5 - 2009/10 | 1.1 | 1.5 | 1.8 |
| 6 - 2011/12 | 1.2 | 1.6 | 1.9 |
| 7 - 2013/14 | 1.3 | 1.7 | 2.1 |
| 8 - 2016/16 | 1.3 | 1.8 | 2.2 |
| 9 - 2017/18 | 1.4 | 1.9 | 2.3 |
| 10 - 2019/20 | 1.4 | 1.8 | 2.3 |

Country 7: **IVORY COAST**

| Period – Years | Low % | Expected % | High % |
|---|---|---|---|
| 1 - 2001/2 | 3.5 | 4.7 | 5.9 |
| 2 - 2003/4 | 5.9 | 7.8 | 9.8 |
| 3 - 2005/6 | 5.4 | 7.3 | 9.1 |
| 4 - 2007/8 | 4.6 | 6.2 | 7.7 |
| 5 - 2009/10 | 3.9 | 5.2 | 6.4 |
| 6 - 2011/12 | 5.0 | 6.7 | 8.4 |
| 7 - 2013/14 | 5.5 | 7.3 | 9.1 |
| 8 - 2016/16 | 5.3 | 7.1 | 8.9 |
| 9 - 2017/18 | 5.8 | 7.8 | 9.7 |
| 10 - 2019/20 | 5.8 | 7.8 | 9.7 |

Country 8: **LIBERIA** (Received May 8, 2001)

| Period – Years | Low % | Expected % | High % |
|---|---|---|---|
| 1 - 2001/2 | | 200.0 | |
| 2 - 2003/4 | | 62.0 | |
| 3 - 2005/6 | | 0 | |
| 4 - 2007/8 | | 0 | |
| 5 - 2009/10 | | 26.0 | |
| 6 - 2011/12 | | 20.0 | |
| 7 - 2013/14 | | 0 | |
| 8 - 2016/16 | | 0 | |
| 9 - 2017/18 | | 0 | |
| 10 - 2019/20 | | 0 | |

Country 9: **MALI**

| Period – Years | Low % | Expected % | High % |
|---|---|---|---|
| 1 - 2001/2 | 12.1 | 16.2 | 20.2 |
| 2 - 2003/4 | 11.2 | 15.0 | 18.7 |
| 3 - 2005/6 | 7.1 | 9.5 | 11.9 |
| 4 - 2007/8 | 4.5 | 6.0 | 7.4 |
| 5 - 2009/10 | 4.5 | 6.0 | 7.4 |
| 6 - 2011/12 | 2.6 | 3.5 | 4.4 |
| 7 - 2013/14 | 2.6 | 3.5 | 4.3 |
| 8 - 2016/16 | 3.0 | 4.0 | 5.0 |
| 9 - 2017/18 | 3.4 | 4.6 | 5.7 |
| 10 - 2019/20 | 3.4 | 4.6 | 5.7 |

Country 10: **NIGER**

| Period – Years | Low % | Expected % | High % |
|---|---|---|---|
| 1 - 2001/2 | 6.0 | 8.1 | 10.1 |
| 2 - 2003/4 | 5.2 | 7.0 | 8.7 |
| 3 - 2005/6 | 5.6 | 7.5 | 9.4 |
| 4 - 2007/8 | 5.5 | 7.3 | 9.1 |
| 5 - 2009/10 | 5.6 | 7.4 | 9.3 |
| 6 - 2011/12 | 5.6 | 7.4 | 9.3 |
| 7 - 2013/14 | 5.5 | 7.4 | 9.2 |
| 8 - 2016/16 | 5.5 | 7.4 | 9.2 |
| 9 - 2017/18 | 5.6 | 7.4 | 9.3 |
| 10 - 2019/20 | 5.5 | 7.4 | 9.2 |

Country 11: **NIGERIA**

| Period – Years | Low % | Expected % | High % |
|---|---|---|---|
| 1 - 2001/2 | 8.7 | 11.7 | 14.6 |
| 2 - 2003/4 | 9.1 | 12.2 | 15.2 |
| 3 - 2005/6 | 8.1 | 10.8 | 13.6 |
| 4 - 2007/8 | 8.7 | 11.6 | 14.5 |
| 5 - 2009/10 | 8.7 | 11.6 | 14.5 |
| 6 - 2011/12 | 8.8 | 11.8 | 14.7 |
| 7 - 2013/14 | 8.6 | 11.5 | 14.3 |
| 8 - 2016/16 | 8.7 | 11.7 | 14.6 |
| 9 - 2017/18 | 8.7 | 11.7 | 14.6 |
| 10 - 2019/20 | 8.6 | 11.4 | 14.3 |

Country 12: **SENEGAL**

| Period – Years | Low % | Expected % | High % |
|---|---|---|---|
| 1 - 2001/2 | 6.3 | 8.5 | 10.6 |
| 2 - 2003/4 | 3.4 | 4.5 | 5.6 |
| 3 - 2005/6 | 6.3 | 8.4 | 10.5 |
| 4 - 2007/8 | 4.6 | 6.1 | 7.6 |
| 5 - 2009/10 | 4.7 | 6.3 | 7.9 |
| 6 - 2011/12 | 5.1 | 6.9 | 8.6 |
| 7 - 2013/14 | 5.2 | 6.9 | 8.6 |
| 8 - 2016/16 | 5.1 | 6.9 | 8.6 |
| 9 - 2017/18 | 5.3 | 7.0 | 8.8 |
| 10 - 2019/20 | 5.3 | 7.1 | 8.8 |

Country 13: **SIERRA LEONE**

| Period – Years | Low % | Expected % | High % |
|---|---|---|---|
| 1 - 2001/2 | 46.2 | 61.7 | 77.1 |
| 2 - 2003/4 | 12.6 | 16.8 | 20.9 |
| 3 - 2005/6 | 4.6 | 6.2 | 7.7 |
| 4 - 2007/8 | 4.7 | 6.2 | 7.8 |
| 5 - 2009/10 | 4.9 | 6.5 | 8.1 |
| 6 - 2011/12 | 5.1 | 6.8 | 8.4 |
| 7 - 2013/14 | 5.1 | 6.8 | 8.4 |
| 8 - 2016/16 | 5.1 | 6.8 | 8.5 |
| 9 - 2017/18 | 5.1 | 6.8 | 8.6 |
| 10 - 2019/20 | 5.1 | 6.8 | 8.5 |

Country 14: **TOGO**

| Period – Years | Low % | Expected % | High % |
|---|---|---|---|
| 1 - 2001/2 | 1.7 | 2.3 | 2.9 |
| 2 - 2003/4 | 1.7 | 2.2 | 2.8 |
| 3 - 2005/6 | 2.9 | 3.8 | 4.8 |
| 4 - 2007/8 | 1.8 | 2.4 | 2.9 |
| 5 - 2009/10 | 2.0 | 2.6 | 3.3 |
| 6 - 2011/12 | 1.9 | 2.5 | 3.1 |
| 7 - 2013/14 | 2.0 | 2.7 | 3.4 |
| 8 - 2016/16 | 1.9 | 2.6 | 3.2 |
| 9 - 2017/18 | 1.8 | 2.5 | 3.1 |
| 10 - 2019/20 | 1.8 | 2.4 | 2.9 |

**Appendix II**

# WAPP Case Studies
# JUNE 2001

## GUINEA & GHANA NATIONAL OUTPUT FILES – With Preliminary Explanations

Based on:
February13-2001.gms model
& ECOWAS Data Set #4 (February 2001)
Expected Demand Growth Rates & 50% Autonomy

**Description of Country Output File** (for the low demand growth scenario)

The first line of the country output file shows the present value (PV) of the total cost of the project. Given the assumptions of "expected demand growth rate and 50% autonomy", the total cost of the project is $US16.5 billion.

The second line gives the country's share of the total cost. In the example country cost share (in PV) for Guinea with the 20-year-horizon is $US1.097 billion, representing 6.6% of the total cost. The country cost share (in PV) of Ghana is $US0.657 billion (4% of total cost).

The next four lines give some information on the execution of the program used to run the model. Then, the rest of the output is arranged by section.

**Section A: CHOSEN PROJECTS** (considering Guinea)
This section lists all the projects selected in the optimal solution of the model.

1. Old thermal expansion
   There would be an expansion of the generation capacity of station 1 and 2 by a total of 20 MW (10 MW each) in period 10 (years 2019 and 2020) of the planning horizon.

2. New hydro projects
   The total capacity added through new hydroelectric projects during the planning horizon is 894 MW.

3. New transmission projects
   A total of 26 MW is added to the transmission capacity through new transmission projects.

4. New transmission expansion
   There is total of 913 MW capacity added through the expansion of new international transmission lines.

**Section B: RESERVES**
This section starts with the Reserve Equation in the model:

*Generation Reserve + Firm Import Reserve – Firm Export Reserve + Unserved Energy = Peak Demand*

The information given by subsection is as follows:

(a) Peak Demand values (MW) from the input files.

(b) Peak Load Carrying Capability (MW) per type of generation plant, adjusted by the Decay Rate (0.1%) and the Reserve Margin (19% for Thermo plants and 10% for Hydro plants).

(c) Firm Import Reserve (MW) adjusted by line loss and forced outage rate (FOR) by exporting country, and in total. Results show that Guinea imports small staggered amount of reserves from Liberia, Mali, Senegal and Sierra Leone. Ghana imports reserves from Côte d'Ivoire in periods 2 to 7 and from Togo in period 7 to 10.

(d) Unadjusted Firm Exports (MW) by country for who reserve is being held. Guinea exports reserves to Côte d'Ivoire and Senegal, and very small amounts to Guinea Bissau and Liberia. Ghana exports reserves to Côte d'Ivoire only in periods 9 and 10 and to Togo in periods 1 to 6.

(f) Total Reserve Capacity (MW): simply adds up left-hand side of the reserve equation to assure the user that it equals the right-hand side.

(g) Total Reserve Margin (%) is the measure of the reliability of the system used by WAPP: "Reserve capacity as a % of System Peak Demand".

(i) Autonomy Factor (actual and required) is the Generation Reserve adjusted by Forced Outage and Decay Rates, divided by Peak Demand. In Guinea the actual autonomy factor is more than the 50% required autonomy level for all periods. In all periods Guinea's total reserves exceed peak demand as shown by actual autonomy always exceeding 100%. Guinea builds new hydropower in the earlier periods for export purposes.

(j) Maximum Imports (MW) is the unadjusted maximum hourly flow of power by country during the year (Part 1). Part 2 lists the Maximum Import per country, year, season, type of day and hour.

(k) Maximum Exports (MW) is the unadjusted maximum hourly flow of power by importing country during the year (Part 1). Part 2 lists the Maximum Export per country, year, season, type of day and hour.

**Section C: INCREMENTAL AND CUMULATIVE GENERATION CAPACITY**
This section shows the yearly incremental and cumulative installed capacity (including initial capacity) by station type, unadjusted for decay or outage rates. This section includes the following subsections:

(a) Incremental unadjusted generation capacity (MW) installed in each year.
(b) Cumulative unadjusted generation capacity (MW) installed in each year
(c) Incremental unadjusted new transmission capacity (MW) per import country
(d) Cumulative unadjusted transmission capacity (MW) per import country

Information in this section can easily be used to construct a table showing yearly and total capacity expansion in a country over the planning horizon.

**Section D: Demand and Supply**
This section begins with an equation showing the equality constraint between Demand and Supply:

*Energy Demand + Energy Exported = Energy Generation + Energy Imported + Unserved Energy*

Section D includes a subsection (a) for total local energy demand and total exports for each year. The last row of subsection (a) shows the sum of the yearly local demand and exports of energy.

Subsection (b) shows the yearly total energy supply by plant type, total imports, and the sum of local energy generation plus imports. The Guinea results show that there is no energy supplied by old thermal production units. This could be the case due to the fact that fuel cost is very high. So, allowing energy generation by existing thermal stations would not meet the cost-minimizing objective of the model.

Subsection (c) details yearly supply by station and shows the load factor per station for generation plant type. The Load factor of a station is its utilization factor and is calculated as follows:

$$\frac{\textit{Supplied MWh in year } t_y \textit{ from station}}{8760 \times \textit{MW capacity of station in year } t_y}$$

It is to be noted that none of Guinea's thermal stations dispatch electricity but uses only the old and new hydropower stations. The thermal station fuel costs are very high.
Subsection (d) lists MWh of energy imported in each year by export country.
Subsection (e) lists exported MWh per year by import country.

**Section E: Costs and Revenues**
There would be a section (a) with fuel cost for old thermal stations, had the model used the thermal stations to generate supply.

Subsection (b) gives the undiscounted O & M cost for the existing new hydro and total O & M cost for the entire planning horizon.

Subsection (c) shows water cost per year for the hydro stations. Water costs are obtained by multiplying MWh (in subsection (c) of section D) by water cost assumed to be $1.5/MWh in the model[1].

Subsection (d) provides information on the capital cost components of the objective function, showing the annual "levelised" (i.e., multiplied by cost recovery factor – crf) cost per year for construction, by station type. Figures are first given in yearly undiscounted, then in yearly discounted (PV) dollars. Total discounted cost for the horizon is given at the end of the section. Total capital cost for Guinea is US $893.98 million, which represents 81 % of the total cost for Guinea (see page 1 of the output). This total cost figure is substantially reduced to about $227 million when adjusted by export revenue and expenditures for imports (see section G).

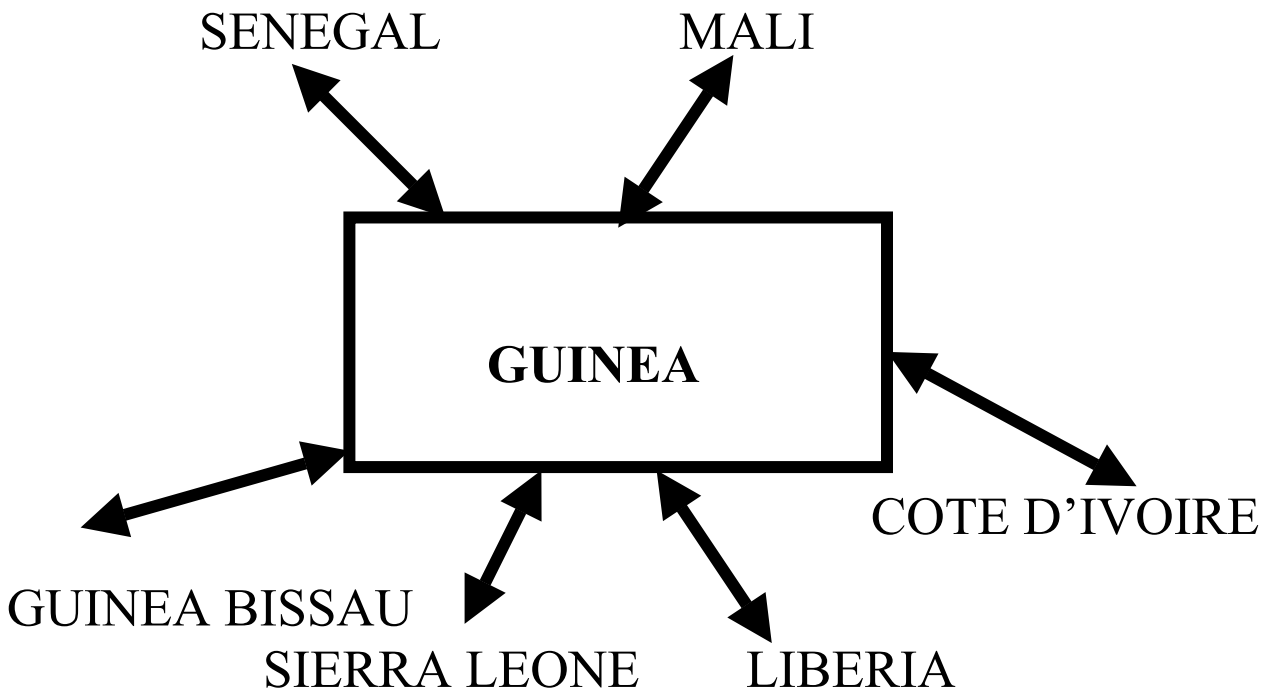
**Section F: Gains from trade**
This section provides the information on the revenues from exports and the payments for imports for trading both energy and reserves. The gain from trade for each exporting country is the increased revenue from trade transactions. The gain from trade for the importing country is the cost savings from not running the more costly domestic generation.


**Section G: Objective Function breakdown**
This section gives the term-by-term breakdown of all terms in the objective function for each year. All values are discounted. Cost components are provided in the subsections

(a) Yearly capital costs by plant
(b) Cost of unserved Megawatts (if any)
(c) Fixed O & M cost associated with construction
(d) Fuel costs
(e) Cost of unserved energy (if any)
(f) Cost of water
(g)Variable O & M costs

# GUINEA

| *Station Name* | *MW* | *Station Type* | *Station Code #* |
|---|---|---|---|
| **Guinea** – *Received Dec11, 2000* | | | |
| TomboI | 12.4 | PGO | Gui Stat1 |
| TomboII | 8.6 | PGO | Gui Stat2 |
| TomboIII | 44.0 | PGO | Gui Stat3 |
| TinkissoKinkon (ROR,1.5+3.2) | 4.7 | H | Gui Stat1 |
| Donkea | 15.0 | H | Gui Stat2 |
| Baneah | 5.0 | H | Gui Stat3 |
| GrandeChutes(ROR) | 27.0 | H | Gui Stat4 |
| Garafiri | 75.0 | H | Gui Stat5 |
| Tiopo | 120.0 | HN | Gui Stat1 |
| ComplexeSouapitiKaleta | 975.0 | HN | Gui Stat2 |
| **Fomi** | 90.0 | HN | Gui Stat3 |
| FelloSounga | 82.0 | HN | Gui Stat4 |
| Gaoual | 39.0 | HN | Gui Stat5 |
| **Morisanako** | 100.0 | HN | Gui Stat6 |
| Koukoutamba | 281.0 | HN | Gui Stat7 |
| Guilde | 45.0 | HN | Gui Stat8 |



Total Regional Cost = $16,521,699,833.97

## Guinea COST FOR HORIZON = 1,097,518,797.33

This Run has 10 Periods. Each Period = 2 years

Program Execution Date 04/26/01
Solver Status = NORMAL COMPLETION
Model Status = OPTIMAL SOLUTION FOUND

A) CHOSEN PROJECTS

Const. Cost is the Construction Cost in Undiscounted Dollars

OLD THERMAL EXPANSION

| Period | Country | Station | Capacity Added | Const. Cost |
|---|---|---|---|---|
| per10 | Gui | Stat1 | 10 MW | $ 8.64E+6 |
| per10 | Gui | Stat2 | 10 MW | $ 8.64E+6 |

NEW HYDRO PROJECTS

| Period | Country | Station | Capacity Added | Const. Cost |
|---|---|---|---|---|
| per1 | Gui | newh2 | 142 MW | $ 1.71E+8 |
| per2 | Gui | newh2 | 437 MW | $ 5.28E+8 |
| per3 | Gui | newh2 | 1 MW | $ 1.40E+6 |
| per4 | Gui | newh2 | 1 MW | $ 1.40E+6 |
| per4 | Gui | newh3 | 43 MW | $ 7.82E+7 |
| per4 | Gui | newh7 | 98 MW | $ 1.54E+8 |
| per5 | Gui | newh2 | 1 MW | $ 1.40E+6 |
| per5 | Gui | newh3 | 0 MW | $ 1.56E+5 |
| per5 | Gui | newh7 | 0 MW | $ 3.08E+5 |
| per6 | Gui | newh2 | 1 MW | $ 1.40E+6 |
| per6 | Gui | newh3 | 0 MW | $ 1.56E+5 |
| per6 | Gui | newh4 | 8 MW | $ 1.65E+7 |
| per6 | Gui | newh7 | 0 MW | $ 3.08E+5 |
| per7 | Gui | newh2 | 1 MW | $ 1.40E+6 |
| per7 | Gui | newh3 | 0 MW | $ 1.56E+5 |
| per7 | Gui | newh4 | 30 MW | $ 5.97E+7 |
| per7 | Gui | newh6 | 60 MW | $ 1.42E+8 |
| per7 | Gui | newh7 | 0 MW | $ 3.08E+5 |
| per8 | Gui | newh2 | 1 MW | $ 1.40E+6 |
| per8 | Gui | newh3 | 0 MW | $ 1.56E+5 |
| per8 | Gui | newh4 | 0 MW | $ 1.52E+5 |

| | | | | |
|---|---|---|---|---|
| per8 | Gui | newh6 | 0 MW | $ 2.84E+5 |
| per8 | Gui | newh7 | 0 MW | $ 3.08E+5 |
| per9 | Gui | newh2 | 1 MW | $ 1.40E+6 |
| per9 | Gui | newh3 | 0 MW | $ 1.56E+5 |
| per9 | Gui | newh4 | 0 MW | $ 1.52E+5 |
| per9 | Gui | newh6 | 0 MW | $ 2.84E+5 |
| per9 | Gui | newh7 | 0 MW | $ 3.08E+5 |
| per10 | Gui | newh1 | 68 MW | $ 1.68E+8 |
| per10 | Gui | newh2 | 1 MW | $ 1.40E+6 |
| per10 | Gui | newh3 | 0 MW | $ 1.56E+5 |
| per10 | Gui | newh4 | 0 MW | $ 1.52E+5 |
| per10 | Gui | newh6 | 0 MW | $ 2.84E+5 |
| per10 | Gui | newh7 | 0 MW | $ 3.08E+5 |

NEW TRANSMISSION PROJECTS

| Period | Between | Capacity Added |
|---|---|---|
| per2 | Gui and ICo | 10 MW |
| per2 | Gui and GBi | 0 MW |
| per2 | Gui and Lib | 0 MW |
| per2 | Gui and Sen | 4 MW |
| per2 | Gui and SLe | 0 MW |
| per3 | Gui and GBi | 0 MW |
| per3 | Gui and Sen | 1 MW |
| per4 | Gui and ICo | 3 MW |
| per4 | Gui and GBi | 0 MW |
| per4 | Gui and Sen | 1 MW |
| per5 | Gui and GBi | 0 MW |
| per5 | Gui and Lib | 0 MW |
| per5 | Gui and Sen | 1 MW |
| per5 | Gui and SLe | 0 MW |
| per6 | Gui and GBi | 0 MW |
| per6 | Gui and Sen | 1 MW |
| per6 | Gui and SLe | 0 MW |
| per7 | Gui and GBi | 0 MW |
| per7 | Gui and Sen | 1 MW |
| per8 | Gui and GBi | 0 MW |
| per8 | Gui and Sen | 1 MW |
| per9 | Gui and Mal | 1 MW |
| per9 | Gui and Sen | 1 MW |
| per10 | Gui and Mal | 0 MW |
| per10 | Gui and Sen | 1 MW |

NEW TRANSMISSION EXPANSION

| Period | Between | Capacity Added |
|---|---|---|
| per2 | Gui and ICo | 326 MW |
| per2 | Gui and GBi | 6 MW |
| per2 | Gui and Lib | 3 MW |
| per2 | Gui and Sen | 143 MW |
| per2 | Gui and SLe | 13 MW |
| per3 | Gui and GBi | 1 MW |
| per3 | Gui and Sen | 20 MW |
| per4 | Gui and ICo | 110 MW |
| per4 | Gui and GBi | 1 MW |
| per4 | Gui and Sen | 24 MW |
| per5 | Gui and GBi | 1 MW |
| per5 | Gui and Lib | 17 MW |
| per5 | Gui and Sen | 21 MW |
| per5 | Gui and SLe | 30 MW |
| per6 | Gui and GBi | 2 MW |
| per6 | Gui and Sen | 22 MW |
| per6 | Gui and SLe | 10 MW |
| per7 | Gui and GBi | 2 MW |
| per7 | Gui and Sen | 24 MW |
| per8 | Gui and GBi | 2 MW |
| per8 | Gui and Sen | 29 MW |
| per9 | Gui and Mal | 30 MW |
| per9 | Gui and Sen | 33 MW |
| per10 | Gui and Mal | 3 MW |
| per10 | Gui and Sen | 37 MW |

## B) RESERVES

(Generation Reserve + Firm Import Reserve - Firm Exports = Peak Demand)

| Year | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 | 2018 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| (a) PEAK DEMAND (MW) (From input files) | 299 | 355 | 399 | 439 | 484 | 534 | 589 | 649 | 716 | 789 |
| (b) PEAK LOAD CARRYING CAPABILITY (MW) (Adjusted by Decay Rate & Reserve Margin) | | | | | | | | | | |
| Old Thermal | 55 | 54 | 54 | 54 | 54 | 54 | 54 | 54 | 54 | 70 |
| Old Hydro | 115 | 115 | 114 | 114 | 114 | 114 | 114 | 113 | 113 | 113 |
| New Hydro | 129 | 527 | 527 | 655 | 655 | 663 | 745 | 745 | 745 | 807 |
| Total | 299 | 696 | 695 | 824 | 823 | 831 | 912 | 912 | 912 | 990 |

(c) FIRM IMPORT RESERVE (MW)
(Adjusted by line loss, forced outage rate)
Imports From:

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Liberia | 0 | 0 | 0 | 0 | 20 | 20 | 18 | 13 | 10 | 8 | |
| Mali | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 31 | |
| Senegal | 0 | 0 | 20 | 28 | 21 | 56 | 0 | 0 | 0 | 0 | |
| Sierra Leone | 0 | 0 | 0 | 13 | 43 | 53 | 52 | 52 | 45 | 41 | |
| Total | 0 | 0 | 20 | 41 | 84 | 128 | 71 | 65 | 83 | 80 | |

(d) FIRM EXPORTS (MW)
(Unadjusted)
Exports to:

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ivory Coast | 0 | 0 | 311 | 416 | 415 | 414 | 369 | 233 | 90 | 0 | |
| Guinea Bissau | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 8 | 11 | |
| Liberia | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Senegal | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 80 | 182 | 271 | |
| Total | 0 | 3 | 317 | 425 | 423 | 424 | 394 | 328 | 279 | 281 | |

(f) TOTAL RESERVE CAPACITY (MW)
[ (b) + (c) - (d) = (e) ]

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 299 | 693 | 399 | 439 | 484 | 534 | 589 | 649 | 716 | 789 | |

(g) TOTAL RESERVE MARGIN (%)
[(b)(Adjusted only by decay)+(c)(Adjusted only by line loss)-(d)-(a)]/[(a)-(c)+(d)]=(f)

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | 11.6% | 115.4% | 10.7% | 10.6% | 10.6% | 10.6% | 10.5% | 10.5% | 10.5% | 10.6% | |

(i) AUTONOMY FACTOR [Generation Reserve(adjusted for FOR, Decay) / Peak Demand]

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Actual | 1.089 | 2.136 | 1.900 | 2.043 | 1.852 | 1.695 | 1.688 | 1.531 | 1.388 | 1.367 | |
| Required | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | 0.500 | |

(j) MAXIMUM IMPORTS (MW)
[Maximum hourly flow of energy during the year unadjusted]
Imports from:

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Guinea Bissau | 0 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 5 | 5 | |
| Liberia | 0 | 3 | 3 | 2 | 20 | 20 | 20 | 20 | 20 | 18 | |
| Mali | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 | 31 | |

```
  Sierra Leone     |       0 |      13 |      13 |      13 |      36 |      46 |
51 |      52 |      47 |      43

(j)   MAXIMUM IMPORTS (MW)
 [Time period from which the maximum import flow come from]
 Maximum Import time:
  FRM |  YEAR | SEASON |   DAY   | HOUR |     MW

  GBi | per2  | winter | peak    | hr9  |      4.6
  GBi | per3  | winter | peak    | hr9  |      4.4
  GBi | per4  | winter | peak    | hr9  |      4.1
  GBi | per5  | winter | peak    | hr9  |      3.8
  GBi | per6  | winter | peak    | hr9  |      3.6
  GBi | per7  | winter | peak    | hr9  |      3.9
  GBi | per8  | winter | peak    | hr9  |      4.3
  GBi | per9  | winter | peak    | hr9  |      4.8
  GBi | per10 | winter | peak    | hr9  |      5.1
  Lib | per2  | summer | peak    | hr9  |      3.1
  Lib | per2  | summer | average | hr9  |      3.1
  Lib | per2  | summer | average | avnt |      3.1
  Lib | per2  | summer | average | avdy |      3.1
  Lib | per2  | winter | peak    | hr9  |      3.1
  Lib | per2  | winter | average | hr9  |      3.1
  Lib | per2  | winter | average | avnt |      3.1
  Lib | per2  | winter | average | hr19 |      3.1
  Lib | per3  | winter | peak    | avdy |      3.0
  Lib | per4  | winter | peak    | avdy |      2.3
  Lib | per5  | summer | offpeak | hr9  |     20.0
  Lib | per5  | summer | offpeak | avnt |     20.0
  Lib | per5  | summer | offpeak | hr19 |     20.0
  Lib | per5  | summer | offpeak | hr20 |     20.0
  Lib | per5  | summer | offpeak | hr21 |     20.0
  Lib | per5  | summer | offpeak | avdy |     20.0
  Lib | per5  | summer | peak    | hr9  |     20.0
  Lib | per5  | summer | peak    | avnt |     20.0
  Lib | per5  | summer | peak    | hr19 |     20.0
  Lib | per5  | summer | peak    | hr20 |     20.0
  Lib | per5  | summer | peak    | hr21 |     20.0
  Lib | per5  | summer | peak    | avdy |     20.0
  Lib | per5  | summer | average | hr9  |     20.0
  Lib | per5  | summer | average | avnt |     20.0
  Lib | per5  | summer | average | hr19 |     20.0
  Lib | per5  | summer | average | hr20 |     20.0
  Lib | per5  | summer | average | hr21 |     20.0
  Lib | per5  | summer | average | avdy |     20.0
  Lib | per5  | winter | offpeak | hr9  |     20.0
  Lib | per5  | winter | offpeak | avnt |     20.0
  Lib | per5  | winter | offpeak | hr19 |     20.0
  Lib | per5  | winter | offpeak | hr20 |     20.0
  Lib | per5  | winter | offpeak | hr21 |     20.0
  Lib | per5  | winter | offpeak | avdy |     20.0
  Lib | per5  | winter | peak    | hr9  |     20.0
  Lib | per5  | winter | peak    | avnt |     20.0
  Lib | per5  | winter | peak    | hr19 |     20.0
  Lib | per5  | winter | peak    | hr20 |     20.0
  Lib | per5  | winter | peak    | hr21 |     20.0
  Lib | per5  | winter | peak    | avdy |     20.0
```

```
Lib | per5  | winter | average | hr9  |     20.0
Lib | per5  | winter | average | avnt |     20.0
Lib | per5  | winter | average | hr19 |     20.0
Lib | per5  | winter | average | hr20 |     20.0
Lib | per5  | winter | average | hr21 |     20.0
Lib | per5  | winter | average | avdy |     20.0
Lib | per6  | summer | offpeak | hr9  |     19.9
Lib | per6  | summer | offpeak | avnt |     19.9
Lib | per6  | summer | offpeak | hr19 |     19.9
Lib | per6  | summer | offpeak | hr20 |     19.9
Lib | per6  | summer | offpeak | hr21 |     19.9
Lib | per6  | summer | offpeak | avdy |     19.9
Lib | per6  | summer | peak    | hr9  |     19.9
Lib | per6  | summer | peak    | avnt |     19.9
Lib | per6  | summer | peak    | hr19 |     19.9
Lib | per6  | summer | peak    | avdy |     19.9
Lib | per6  | summer | average | hr9  |     19.9
Lib | per6  | summer | average | avnt |     19.9
Lib | per6  | summer | average | hr19 |     19.9
Lib | per6  | summer | average | hr20 |     19.9
Lib | per6  | summer | average | avdy |     19.9
Lib | per6  | winter | offpeak | hr9  |     19.9
Lib | per6  | winter | offpeak | avnt |     19.9
Lib | per6  | winter | offpeak | hr19 |     19.9
Lib | per6  | winter | offpeak | hr20 |     19.9
Lib | per6  | winter | offpeak | hr21 |     19.9
Lib | per6  | winter | offpeak | avdy |     19.9
Lib | per6  | winter | peak    | hr9  |     19.9
Lib | per6  | winter | peak    | avnt |     19.9
Lib | per6  | winter | peak    | avdy |     19.9
Lib | per6  | winter | average | hr9  |     19.9
Lib | per6  | winter | average | avnt |     19.9
Lib | per6  | winter | average | hr19 |     19.9
Lib | per6  | winter | average | hr20 |     19.9
Lib | per6  | winter | average | avdy |     19.9
Lib | per7  | summer | offpeak | hr9  |     19.9
Lib | per7  | summer | offpeak | avnt |     19.9
Lib | per7  | summer | offpeak | hr19 |     19.9
Lib | per7  | summer | offpeak | avdy |     19.9
Lib | per7  | summer | peak    | hr9  |     19.9
Lib | per7  | summer | peak    | avnt |     19.9
Lib | per7  | summer | peak    | avdy |     19.9
Lib | per7  | summer | average | hr9  |     19.9
Lib | per7  | summer | average | avnt |     19.9
Lib | per7  | summer | average | hr19 |     19.9
Lib | per7  | summer | average | hr20 |     19.9
Lib | per7  | summer | average | avdy |     19.9
Lib | per7  | winter | offpeak | hr9  |     19.9
Lib | per7  | winter | offpeak | avnt |     19.9
Lib | per7  | winter | offpeak | hr19 |     19.9
Lib | per7  | winter | offpeak | hr20 |     19.9
Lib | per7  | winter | offpeak | avdy |     19.9
Lib | per7  | winter | peak    | hr9  |     19.9
Lib | per7  | winter | peak    | avnt |     19.9
Lib | per7  | winter | peak    | avdy |     19.9
Lib | per7  | winter | average | hr9  |     19.9
Lib | per7  | winter | average | avnt |     19.9
```

| | | | | | |
|---|---|---|---|---|---|
| Lib | per7 | winter | average | hr19 | 19.9 |
| Lib | per7 | winter | average | avdy | 19.9 |
| Lib | per8 | summer | offpeak | avdy | 19.8 |
| Lib | per8 | summer | peak | hr9 | 19.8 |
| Lib | per8 | summer | peak | avnt | 19.8 |
| Lib | per8 | summer | peak | avdy | 19.8 |
| Lib | per8 | summer | average | hr9 | 19.8 |
| Lib | per8 | summer | average | avnt | 19.8 |
| Lib | per8 | summer | average | hr19 | 19.8 |
| Lib | per8 | summer | average | avdy | 19.8 |
| Lib | per8 | winter | offpeak | avdy | 19.8 |
| Lib | per8 | winter | peak | hr9 | 19.8 |
| Lib | per8 | winter | peak | avnt | 19.8 |
| Lib | per8 | winter | peak | avdy | 19.8 |
| Lib | per8 | winter | average | hr9 | 19.8 |
| Lib | per8 | winter | average | avnt | 19.8 |
| Lib | per8 | winter | average | hr19 | 19.8 |
| Lib | per8 | winter | average | avdy | 19.8 |
| Lib | per9 | winter | average | hr19 | 19.6 |
| Lib | per10 | winter | average | hr19 | 18.2 |
| Mal | per9 | winter | average | avdy | 28.3 |
| Mal | per10 | summer | offpeak | hr20 | 31.4 |
| Mal | per10 | summer | offpeak | hr21 | 31.4 |
| Mal | per10 | summer | offpeak | avdy | 31.4 |
| Mal | per10 | summer | peak | hr19 | 31.4 |
| Mal | per10 | summer | peak | hr20 | 31.4 |
| Mal | per10 | summer | peak | hr21 | 31.4 |
| Mal | per10 | summer | average | hr19 | 31.4 |
| Mal | per10 | summer | average | hr20 | 31.4 |
| Mal | per10 | summer | average | hr21 | 31.4 |
| Mal | per10 | winter | offpeak | hr20 | 31.4 |
| Mal | per10 | winter | offpeak | hr21 | 31.4 |
| Mal | per10 | winter | peak | hr19 | 31.4 |
| Mal | per10 | winter | peak | hr20 | 31.4 |
| Mal | per10 | winter | peak | hr21 | 31.4 |
| Mal | per10 | winter | average | hr19 | 31.4 |
| Mal | per10 | winter | average | hr20 | 31.4 |
| Mal | per10 | winter | average | hr21 | 31.4 |
| SLe | per2 | winter | average | avdy | 13.0 |
| SLe | per3 | summer | offpeak | hr9 | 13.0 |
| SLe | per3 | summer | offpeak | avnt | 13.0 |
| SLe | per3 | summer | offpeak | hr20 | 13.0 |
| SLe | per3 | summer | offpeak | hr21 | 13.0 |
| SLe | per3 | summer | offpeak | avdy | 13.0 |
| SLe | per3 | summer | peak | avnt | 13.0 |
| SLe | per3 | summer | peak | hr20 | 13.0 |
| SLe | per3 | summer | average | hr9 | 13.0 |
| SLe | per3 | summer | average | avnt | 13.0 |
| SLe | per3 | summer | average | hr19 | 13.0 |
| SLe | per3 | summer | average | hr21 | 13.0 |
| SLe | per3 | summer | average | avdy | 13.0 |
| SLe | per3 | winter | offpeak | hr9 | 13.0 |
| SLe | per3 | winter | offpeak | hr19 | 13.0 |
| SLe | per3 | winter | offpeak | avdy | 13.0 |
| SLe | per3 | winter | peak | hr20 | 13.0 |
| SLe | per3 | winter | peak | hr21 | 13.0 |
| SLe | per3 | winter | average | avnt | 13.0 |

| | | | | | |
|---|---|---|---|---|---|
| SLe | per3 | winter | average | hr19 | 13.0 |
| SLe | per3 | winter | average | hr21 | 13.0 |
| SLe | per3 | winter | average | avdy | 13.0 |
| SLe | per4 | summer | offpeak | hr9 | 12.9 |
| SLe | per4 | summer | offpeak | avnt | 12.9 |
| SLe | per4 | summer | offpeak | hr19 | 12.9 |
| SLe | per4 | summer | offpeak | hr20 | 12.9 |
| SLe | per4 | summer | offpeak | hr21 | 12.9 |
| SLe | per4 | summer | offpeak | avdy | 12.9 |
| SLe | per4 | summer | peak | hr9 | 12.9 |
| SLe | per4 | summer | peak | avnt | 12.9 |
| SLe | per4 | summer | peak | hr21 | 12.9 |
| SLe | per4 | summer | peak | avdy | 12.9 |
| SLe | per4 | summer | average | avnt | 12.9 |
| SLe | per4 | summer | average | hr19 | 12.9 |
| SLe | per4 | summer | average | hr20 | 12.9 |
| SLe | per4 | summer | average | hr21 | 12.9 |
| SLe | per4 | winter | offpeak | hr19 | 12.9 |
| SLe | per4 | winter | offpeak | hr21 | 12.9 |
| SLe | per4 | winter | peak | hr9 | 12.9 |
| SLe | per4 | winter | peak | avnt | 12.9 |
| SLe | per4 | winter | peak | hr20 | 12.9 |
| SLe | per4 | winter | average | hr9 | 12.9 |
| SLe | per4 | winter | average | avnt | 12.9 |
| SLe | per4 | winter | average | hr19 | 12.9 |
| SLe | per4 | winter | average | hr20 | 12.9 |
| SLe | per5 | winter | average | avnt | 36.2 |
| SLe | per6 | winter | peak | hr20 | 45.7 |
| SLe | per7 | winter | peak | hr20 | 51.0 |
| SLe | per8 | winter | average | hr20 | 51.7 |
| SLe | per9 | winter | average | hr20 | 46.6 |
| SLe | per10 | winter | peak | hr20 | 43.5 |

(k) MAXIMUM EXPORTS (MW)
[Maximum hourly flow of energy during the year unadjusted]
Exports to:

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ivory Coast | 0 | 312 | 311 | 416 | 415 | 394 | 413 | 410 | 305 | 312 | |
| Guinea Bissau | 0 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | |
| Liberia | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | |
| Senegal | 0 | 133 | 151 | 173 | 193 | 213 | 235 | 262 | 292 | 325 | |
| Sierra Leone | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 24 | |

(j) MAXIMUM EXPORTS (MW)
[Time period from which the maximum export flow come from]
Maximum Export time:

| TO | YEAR | SEASON | DAY | HOUR | MW |
|---|---|---|---|---|---|
| ICo | per2 | summer | offpeak | avnt | 312.1 |
| ICo | per2 | summer | offpeak | hr20 | 312.1 |
| ICo | per2 | summer | offpeak | avdy | 312.1 |
| ICo | per2 | summer | peak | hr9 | 312.1 |

| | | | | | |
|---|---|---|---|---|---|
| ICo | per2 | summer | peak | avnt | 312.1 |
| ICo | per2 | summer | peak | hr19 | 312.1 |
| ICo | per2 | summer | peak | hr20 | 312.1 |
| ICo | per2 | summer | peak | hr21 | 312.1 |
| ICo | per2 | summer | peak | avdy | 312.1 |
| ICo | per2 | summer | average | hr9 | 312.1 |
| ICo | per2 | summer | average | hr19 | 312.1 |
| ICo | per2 | summer | average | hr20 | 312.1 |
| ICo | per2 | summer | average | avdy | 312.1 |
| ICo | per2 | winter | offpeak | avnt | 312.1 |
| ICo | per2 | winter | offpeak | hr20 | 312.1 |
| ICo | per2 | winter | offpeak | avdy | 312.1 |
| ICo | per2 | winter | peak | hr9 | 312.1 |
| ICo | per2 | winter | peak | avnt | 312.1 |
| ICo | per2 | winter | peak | hr19 | 312.1 |
| ICo | per2 | winter | peak | hr20 | 312.1 |
| ICo | per2 | winter | peak | hr21 | 312.1 |
| ICo | per2 | winter | peak | avdy | 312.1 |
| ICo | per2 | winter | average | hr9 | 312.1 |
| ICo | per2 | winter | average | avnt | 312.1 |
| ICo | per2 | winter | average | hr19 | 312.1 |
| ICo | per2 | winter | average | hr20 | 312.1 |
| ICo | per2 | winter | average | avdy | 312.1 |
| ICo | per3 | summer | peak | hr9 | 311.5 |
| ICo | per3 | winter | peak | hr9 | 311.5 |
| ICo | per3 | winter | average | hr9 | 311.5 |
| ICo | per3 | winter | average | avnt | 311.5 |
| ICo | per4 | winter | peak | hr9 | 415.9 |
| ICo | per4 | winter | average | hr19 | 415.9 |
| ICo | per5 | winter | peak | hr9 | 415.1 |
| ICo | per6 | winter | average | hr19 | 394.2 |
| ICo | per7 | summer | offpeak | hr9 | 413.5 |
| ICo | per7 | winter | offpeak | hr9 | 413.5 |
| ICo | per7 | winter | average | avdy | 413.5 |
| ICo | per8 | winter | average | hr9 | 410.3 |
| ICo | per9 | winter | average | hr19 | 305.3 |
| ICo | per10 | winter | average | hr19 | 312.4 |
| GBi | per2 | summer | offpeak | hr21 | 6.0 |
| GBi | per2 | summer | peak | hr21 | 6.0 |
| GBi | per3 | summer | offpeak | hr20 | 7.2 |
| GBi | per4 | summer | offpeak | hr20 | 7.9 |
| GBi | per4 | summer | offpeak | hr21 | 7.9 |
| GBi | per4 | summer | peak | hr21 | 7.9 |
| GBi | per5 | summer | offpeak | hr20 | 8.7 |
| GBi | per5 | summer | offpeak | hr21 | 8.7 |
| GBi | per5 | summer | peak | hr21 | 8.7 |
| GBi | per6 | summer | offpeak | hr21 | 9.8 |
| GBi | per7 | summer | offpeak | hr21 | 10.8 |
| GBi | per8 | summer | offpeak | hr21 | 11.9 |
| GBi | per9 | summer | offpeak | hr21 | 13.1 |
| GBi | per10 | summer | offpeak | hr21 | 14.1 |
| GBi | per10 | summer | peak | hr21 | 14.1 |
| Lib | per4 | summer | offpeak | hr21 | 0.5 |
| Sen | per2 | summer | average | avdy | 132.6 |
| Sen | per3 | summer | offpeak | hr21 | 151.3 |
| Sen | per3 | summer | peak | hr20 | 151.3 |
| Sen | per3 | summer | peak | hr21 | 151.3 |

```
  Sen | per3  | summer | peak    | avdy |    151.3
  Sen | per3  | summer | average | hr20 |    151.3
  Sen | per3  | summer | average | hr21 |    151.3
  Sen | per3  | winter | peak    | hr21 |    151.3
  Sen | per3  | winter | average | hr20 |    151.3
  Sen | per3  | winter | average | hr21 |    151.3
  Sen | per4  | summer | offpeak | hr21 |    173.3
  Sen | per4  | summer | peak    | hr20 |    173.3
  Sen | per4  | summer | peak    | hr21 |    173.3
  Sen | per4  | summer | peak    | avdy |    173.3
  Sen | per4  | summer | average | hr20 |    173.3
  Sen | per4  | summer | average | hr21 |    173.3
  Sen | per4  | winter | peak    | hr21 |    173.3
  Sen | per4  | winter | average | hr21 |    173.3
  Sen | per5  | winter | peak    | hr21 |    192.7
  Sen | per6  | summer | offpeak | hr21 |    212.6
  Sen | per6  | summer | peak    | hr20 |    212.6
  Sen | per6  | summer | peak    | hr21 |    212.6
  Sen | per6  | summer | average | hr20 |    212.6
  Sen | per6  | summer | average | hr21 |    212.6
  Sen | per6  | winter | peak    | hr21 |    212.6
  Sen | per7  | summer | peak    | hr21 |    234.8
  Sen | per8  | summer | offpeak | hr21 |    261.6
  Sen | per8  | summer | peak    | hr20 |    261.6
  Sen | per8  | summer | peak    | hr21 |    261.6
  Sen | per8  | summer | peak    | avdy |    261.6
  Sen | per8  | summer | average | hr20 |    261.6
  Sen | per8  | summer | average | hr21 |    261.6
  Sen | per8  | winter | peak    | hr21 |    261.6
  Sen | per8  | winter | average | hr21 |    261.6
  Sen | per9  | summer | peak    | avdy |    291.6
  Sen | per10 | summer | offpeak | hr21 |    325.3
  Sen | per10 | summer | peak    | hr20 |    325.3
  Sen | per10 | summer | peak    | hr21 |    325.3
  Sen | per10 | summer | peak    | avdy |    325.3
  Sen | per10 | summer | average | hr20 |    325.3
  Sen | per10 | summer | average | hr21 |    325.3
  Sen | per10 | winter | peak    | hr21 |    325.3
  Sen | per10 | winter | average | hr21 |    325.3
  SLe | per9  | summer | offpeak | hr9  |     20.0
  SLe | per10 | summer | offpeak | avnt |     24.0


======================================================================
         C)   INCREMENTAL AND CUMULATIVE GENERATION CAPACITY
======================================================================
(a)   GENERATION CAPACITY (MW)   [Unadjusted]
 Incremental
  Old Thermal      |       0 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |       0 |      20
  New Hydro        |     142 |     437 |       1 |     143 |       1 |      10 |
92 |       2 |       2 |      70

(b)   GENERATION CAPACITY (MW)   [Unadjusted]
 Cumulative
```

```
  Old Thermal      |      65 |      65 |      65 |      65 |      65 |      65 |
65 |      65 |      65 |      85
  New Hydro        |     142 |     579 |     581 |     723 |     725 |     735 |
826 |     828 |     830 |     900
  Old Hydro        |     127 |     127 |     127 |     127 |     127 |     127 |
127 |     127 |     127 |     127

(c)   NEW TRANSMISSION CAPACITY (MW)   [Unadjusted]
 Incremental
  Ivory Coast      |       0 |     336 |       0 |     113 |       0 |       0 |
0 |       0 |       0 |       0
  Guinea Bissau    |       0 |       6 |       1 |       1 |       1 |       2 |
2 |       2 |       0 |       0
  Liberia          |       0 |       3 |       0 |       0 |      18 |       0 |
0 |       0 |       0 |       0
  Mali             |       0 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |      30 |       3
  Senegal          |       0 |     147 |      21 |      25 |      22 |      23 |
25 |      30 |      34 |      38
  Sierra Leone     |       0 |      13 |       0 |       0 |      31 |      10 |
0 |       0 |       0 |       0

(d)   NEW TRANSMISSION CAPACITY (MW)   [Unadjusted]
 Cumulative
  Ivory Coast      |       0 |     336 |     336 |     449 |     449 |     449 |
449 |     449 |     449 |     449
  Guinea Bissau    |       0 |       6 |       7 |       8 |       9 |      11 |
13 |      15 |      15 |      15
  Liberia          |       0 |       3 |       3 |       3 |      21 |      21 |
21 |      21 |      21 |      21
  Mali             |       0 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |      30 |      34
  Senegal          |       0 |     147 |     168 |     193 |     215 |     238 |
263 |     293 |     327 |     365
  Sierra Leone     |       0 |      13 |      13 |      13 |      44 |      55 |
55 |      55 |      55 |      55

================================================================================


                    D)   DEMAND/SUPPLY
================================================================================


 (Energy Demand + Energy Exported + Energy Dumped = Energy Generation + Energy
Imported + Energy Unserved)
 --------------------------------------------------------------------------

(a)   ENERGY DEMAND (MWh/Year)   [Yearly Total]
 Local Demand      | 1556792 | 1849624 | 2135621 | 2376544 | 2620140 | 2888704 |
3184796 | 3511238 | 3871140 | 4267932
  Exports          |       0 | 3808419 | 3495939 | 4457496 | 4373974 | 4155219 |
4788646 | 4450838 | 4123168 | 4133574
 Total             | 1556792 | 5658043 | 5631560 | 6834040 | 6994114 | 7043923 |
7973442 | 7962076 | 7994308 | 8401506
```

(b) ENERGY SUPPLY (MWh/Year) [Yearly Total]

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Old Thermal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Old Hydro | 325173 | 493500 | 493500 | 493500 | 493500 | 493500 | 493500 | 493500 | 493500 | 493500 | 493500 |
| New Hydro | 1231618 | 5023000 | 5023000 | 6255000 | 6255000 | 6326887 | 7110700 | 7110700 | 7110700 | 7700700 | |
| Imports | 0 | 141543 | 115060 | 85540 | 245614 | 223536 | 369242 | 357876 | 390108 | 207306 | |
| Total | 1556792 | 5658043 | 5631560 | 6834040 | 6994114 | 7043923 | 7973442 | 7962076 | 7994308 | 8401506 | |

(c) SUPPLY, BY STATION TYPE

Old Thermal Generation (MWh) [Yearly, by Station]

| Station: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stat1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stat2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Stat3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Old Thermal Load Factor [Yearly, by Station]

| Station: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stat1 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Stat2 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Stat3 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Old Hydro Generation (MWh) [Yearly, by Station]

| Station: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stat1 | 9500 | 9500 | 9500 | 9500 | 9500 | 9500 | 9500 | 9500 | 9500 | 9500 | 9500 |
| Stat2 | 70000 | 70000 | 70000 | 70000 | 70000 | 70000 | 70000 | 70000 | 70000 | 70000 | 70000 |
| Stat3 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 |
| Stat4 | 140000 | 140000 | 140000 | 140000 | 140000 | 140000 | 140000 | 140000 | 140000 | 140000 | 140000 |
| Stat5 | 95673 | 264000 | 264000 | 264000 | 264000 | 264000 | 264000 | 264000 | 264000 | 264000 | 264000 |
| Total | 325173 | 493500 | 493500 | 493500 | 493500 | 493500 | 493500 | 493500 | 493500 | 493500 | 493500 |

Old Hydro Load Factor [Yearly, by Station]

| Station: | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Stat1 | 23.12 | 23.17 | 23.21 | 23.26 | 23.31 | 23.35 | 23.40 | 23.45 | 23.49 | 23.54 | |
| Stat2 | 53.38 | 53.49 | 53.59 | 53.70 | 53.81 | 53.92 | 54.02 | 54.13 | 54.24 | 54.35 | |
| Stat3 | 22.88 | 22.92 | 22.97 | 23.01 | 23.06 | 23.11 | 23.15 | 23.20 | 23.25 | 23.29 | |

```
  Stat4             |   59.31 |   59.43 |   59.55 |   59.67 |   59.79 |   59.91 |
60.03 |   60.15 |   60.27 |   60.39
  Stat5             |   14.59 |   40.34 |   40.42 |   40.51 |   40.59 |   40.67 |
40.75 |   40.83 |   40.91 |   40.99

New Hydro Generation (MWh)   [Yearly, by Station]
 Station:
  newh1             |       0 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |       0 |  590000
  newh2             | 1231618 | 5023000 | 5023000 | 5023000 | 5023000 | 5023000 |
5023000 | 5023000 | 5023000 | 5023000
  newh3             |       0 |       0 |       0 |  374000 |  374000 |  374000 |
374000 |  374000 |  374000 |  374000
  newh4             |       0 |       0 |       0 |       0 |       0 |   71887 |
332700 |  332700 |  332700 |  332700
  newh6             |       0 |       0 |       0 |       0 |       0 |       0 |
523000 |  523000 |  523000 |  523000
  newh7             |       0 |       0 |       0 |  858000 |  858000 |  858000 |
858000 |  858000 |  858000 |  858000
 Total              | 1231618 | 5023000 | 5023000 | 6255000 | 6255000 | 6326887 |
7110700 | 7110700 | 7110700 | 7700700

New Hydro Load Factor   [Yearly, by Station]
 Station:
  newh1             |    0.00 |    0.00 |    0.00 |    0.00 |    0.00 |    0.00 |
0.00 |    0.00 |    0.00 |   98.86
  newh2             |   99.00 |   99.00 |   99.00 |   99.00 |   99.00 |   99.00 |
99.00 |   99.00 |   99.00 |   99.00
  newh3             |    0.00 |    0.00 |    0.00 |   98.86 |   98.86 |   98.86 |
98.86 |   98.86 |   98.86 |   98.86
  newh4             |    0.00 |    0.00 |    0.00 |    0.00 |    0.00 |   98.86 |
98.86 |   98.86 |   98.86 |   98.86
  newh6             |    0.00 |    0.00 |    0.00 |    0.00 |    0.00 |    0.00 |
99.00 |   99.00 |   99.00 |   99.00
  newh7             |    0.00 |    0.00 |    0.00 |   99.50 |   99.50 |   99.50 |
99.50 |   99.50 |   99.50 |   99.50

(D)   ENERGY IMPORTED (MWh/Year)
 Imported From:
  Guinea Bissau     |       0 |    2943 |    1788 |     692 |     252 |     133 |
147 |     162 |     179 |     168
  Liberia           |       0 |   24837 |   18312 |   12016 |  174843 |  174494 |
173810 |  171938 |  138401 |  126329
  Mali              |       0 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |  223820 |   65935
  Sierra Leone      |       0 |  113763 |   94960 |   72832 |   70519 |   48909 |
195285 |  185775 |   27708 |   14874
 Total              |       0 |  141543 |  115060 |   85540 |  245614 |  223536 |
369242 |  357876 |  390108 |  207306

(e)   ENERGY EXPORTED (MWh/Year)
 Exported To:
  Ivory Coast       |       0 | 2721934 | 2252506 | 3041322 | 2796046 | 2410749 |
2863267 | 2307101 | 1671249 | 1361805
  Guinea Bissau     |       0 |   16766 |   23410 |   30678 |   38347 |   46654 |
51436 |   56708 |   62520 |   69737
```

```
  Liberia          |       0 |       0 |       0 |     133 |       0 |       0 |
0 |       0 |       0 |       0
  Senegal          |       0 | 1069719 | 1220023 | 1385363 | 1539581 | 1697816 |
1873943 | 2087029 | 2325829 | 2593635
  Sierra Leone     |       0 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |   63569 |  108397
 Total             |       0 | 3808419 | 3495939 | 4457496 | 4373974 | 4155219 |
4788646 | 4450838 | 4123168 | 4133574

========================================================================
                    E)   COST & REVENUES
========================================================================

(b)   O & M COSTS ($/Year)
 Undiscounted
  Old Hydro        |  842860 | 2245020 | 2245020 | 2245020 | 2245020 | 2245020 |
2245020 | 2245020 | 2245020 | 2245020
  New Hydro        | 3210478 | 1.31E+7 | 1.31E+7 | 1.66E+7 | 1.66E+7 | 1.70E+7 |
2.12E+7 | 2.13E+7 | 2.13E+7 | 2.48E+7

 Total Discounted O & M Cost for Horizon = $141247249

(c)   WATER COSTS ($/Year)
 Undiscounted
  Old Hydro        |  162587 |  246750 |  246750 |  246750 |  246750 |  246750 |
246750 |  246750 |  246750 |  246750
  New Hydro        |  615809 | 2511500 | 2511500 | 3127500 | 3127500 | 3163444 |
3555350 | 3555350 | 3555350 | 3850350

 Total Discounted Water Cost for Horizon = $24530942


(d)   CAPITAL COSTS

 levelized(t) = (construction cost)(crf) in all t following construction

Year   |    2002 |    2004 |    2006 |    2008 |    2010 |    2012 |    2014 |
2016 |    2018 |    2020 |    Total


                       NEW HYDRO STATIONS
Station            Undiscounted Levelized Dollars
 newh1 |      0  |      0  |      0  |      0  |      0  |      0  |      0  |
0  |      0  | 2.2E+7  | 2.2E+7
 newh2 | 2.3E+7  | 9.2E+7  | 9.3E+7  | 9.3E+7  | 9.3E+7  | 9.3E+7  | 9.3E+7  |
9.3E+7  | 9.4E+7  | 9.4E+7  | 8.6E+8
 newh3 |      0  |      0  |      0  | 1.0E+7  | 1.0E+7  | 1.0E+7  | 1.0E+7  |
1.0E+7  | 1.0E+7  | 1.0E+7  | 7.3E+7
 newh4 |      0  |      0  |      0  |      0  |      0  | 2.2E+6  | 1.0E+7  |
1.0E+7  | 1.0E+7  | 1.0E+7  | 4.3E+7
 newh6 |      0  |      0  |      0  |      0  |      0  |      0  | 1.9E+7  |
1.9E+7  | 1.9E+7  | 1.9E+7  | 7.5E+7
 newh7 |      0  |      0  |      0  | 2.0E+7  | 2.0E+7  | 2.0E+7  | 2.0E+7  |
2.1E+7  | 2.1E+7  | 2.1E+7  | 1.4E+8
Station            Discounted Levelized Dollars
 newh1 |      0  |      0  |      0  |      0  |      0  |      0  |      0  |
0  |      0  | 3.6E+6  | 3.6E+6
```

```
 newh2 | 2.1E+7  | 6.9E+7  | 5.7E+7  | 4.8E+7  | 3.9E+7  | 3.3E+7  | 2.7E+7  |
2.2E+7  | 1.8E+7  | 1.5E+7  | 3.5E+8
 newh3 |      0  |      0  |      0  | 5.3E+6  | 4.4E+6  | 3.6E+6  | 3.0E+6  |
2.5E+6  | 2.1E+6  | 1.7E+6  | 2.3E+7
 newh4 |      0  |      0  |      0  |      0  |      0  | 777183  | 3.0E+6  |
2.5E+6  | 2.0E+6  | 1.7E+6  | 9.9E+6
 newh6 |      0  |      0  |      0  |      0  |      0  |      0  | 5.4E+6  |
4.5E+6  | 3.7E+6  | 3.1E+6  | 1.7E+7
 newh7 |      0  |      0  |      0  | 1.0E+7  | 8.6E+6  | 7.1E+6  | 5.9E+6  |
4.9E+6  | 4.1E+6  | 3.4E+6  | 4.4E+7

 Total Discounted Cost for Horizon = $893984588

================================================================================

                    F)   GAINS FROM TRADE
================================================================================


Year         |    2002  |    2004  |    2006  |    2008  |    2010  |    2012  |
2014  |    2016  |    2018  |    2020
REVENUE FROM EXPORTS
 EXPORTED TO:
  Ivory Coas|         0|  98120577|  73916963|  88163553|  66990997|  50662248|
51824693|  34473258|  18399865|  11163486
  Guinea Bis|         0|    676138|    867348|    986401|   1010810|   1017614|
966318|    880069|    718128|    625201
  Liberia   |         0|         0|         0|      3966|         0|         0|
0|         0|         0|         0
  Senegal   |         0|  40197157|  43229382|  43256799|  39731994|  38349218|
36403472|  33476863|  27636582|  23072184
  Sierra Leo|         0|         0|         0|         0|         0|         0|
0|         0|    707253|    894710

PAYMENTS FOR IMPORTS
 IMPORTED FROM:
  Guinea Bis|         0|    105085|     60734|     20805|      6268|      2904|
2758|      2507|      2010|      1403
  Liberia   |         0|    792657|    615883|    357466|   4187936|   3588552|
3190753|   2610379|   1565548|   1064557
  Mali      |         0|         0|         0|         0|         0|         0|
0|         0|   2499895|    582812
  Sierra Leo|         0|   3666638|   3195017|   2166778|   1734742|   1059108|
3629224|   2855359|    366500|    160424


REVENUE FROM RESERVES
 EXPORTED TO:
  Ivory Coas|         0|         0|   2532406|   5337793|  13929394|  14769342|
17958504|  10174827|   4497565|         0
  Guinea Bis|         0|         0|         1|         1|    151345|    373234|
676179|    746699|    393862|    609299
  Liberia   |         0|         0|         0|      4532|         0|         0|
0|         0|         0|         0
  Senegal   |         0|         0|         0|         0|         0|         0|
650500|   3622679|   9395011|  15591167
```

PAYMENTS FOR RESERVES
 IMPORTED FROM:
  Liberia   |         0|         0|         0|         0|    340248|    490619|
909161|    563926|    531532|    454220
  Mali      |         0|         0|         0|         0|         0|         0|
0|         0|   1369640|   1698982
  Senegal   |         0|         0|         1|         4|    420055|   1730009|
0|         0|         0|         0
  Sierra Leo|         0|         0|         0|         1|    552378|   1279188|
1990810|   2311432|   2282125|   2330551

| Year | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 | 2018 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| Average Buying Price Present Value | 0.00 | 16.12 | 16.82 | 14.88 | 12.07 | 10.40 | 9.24 | 7.64 | 5.68 | 4.36 |
| Average Selling Price Present Value | 0.00 | 19.01 | 17.54 | 15.45 | 12.79 | 11.23 | 9.66 | 8.00 | 5.93 | 4.44 |
| Average Buying Price Real Dollars | 0.00 | 21.49 | 27.14 | 29.03 | 28.50 | 29.72 | 31.94 | 31.96 | 28.77 | 26.73 |
| Average Selling Price Real Dollars | 0.00 | 25.34 | 28.29 | 30.16 | 30.21 | 32.09 | 33.40 | 33.46 | 30.02 | 27.22 |

| Year | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 | 2018 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| Average Buying Price Present Value | 0 | 0 | 0 | 0 | 7827 | 13672 | 20525 | 22137 | 25137 | 27947 |
| Average Selling Price Present Value | 0 | 0 | 4202 | 6613 | 17517 | 18759 | 25684 | 23102 | 26271 | 29234 |
| Average Buying Price Real Dollars | 0 | 0 | 0 | 0 | 18484 | 39068 | 70964 | 92610 | 127248 | 171179 |
| Average Selling Price Real Dollars | 0 | 0 | 6778 | 12907 | 41366 | 53602 | 88803 | 96650 | 132989 | 179066 |

==========

G)  OBJECTIVE FUNCTION BREAKDOWN  (Present Value)

==========

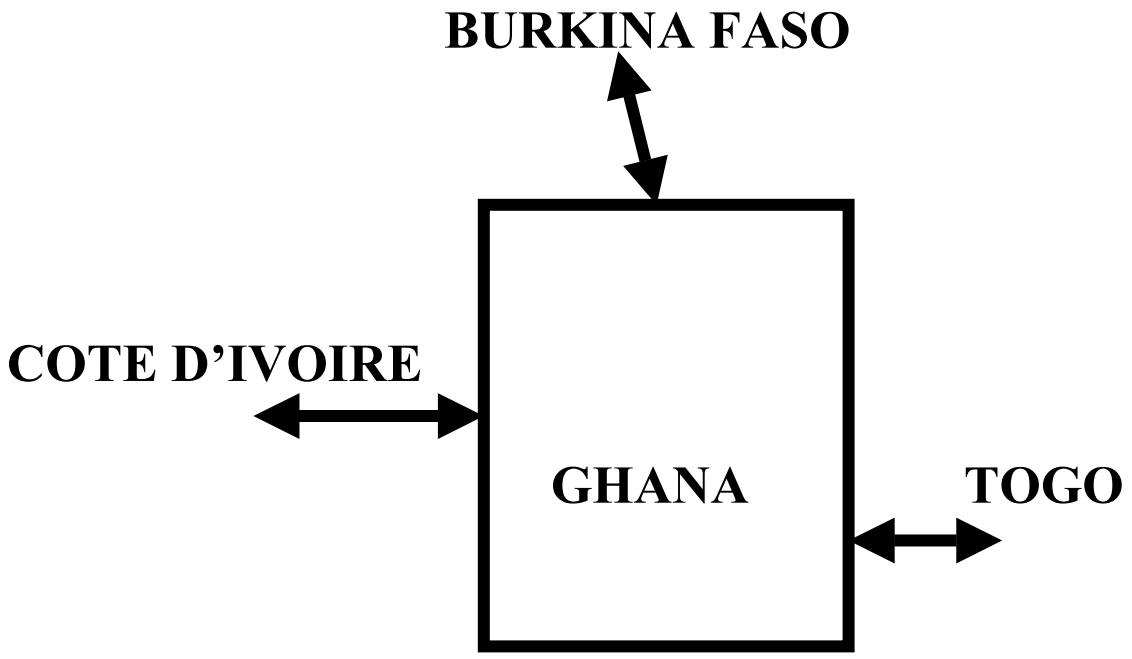
| Year | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 | 2018 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| FIXED COSTS | | | | | | | | | | |
| (a) Capital Costs | | | | | | | | | | |
| OT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 918001 |
| LC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

```
   CC       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   CT       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   SC       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   Old H    |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   New H    |  41083035| 138540607| 114725136| 126433239| 104698455|  88254060|
88591372|  73361264|  60749188|  57548232
   Pumped H |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   New Line |         0|   5820534|   5037071|   5237559|   4800805|   4161852|
3569221|   3076787|   2749881|   2384308
   Old Line |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
  (b) Unserved MegaWatts
   UM       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
  (c) Fixed O&M
   LC       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   CC       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   CT       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   SC       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   New H    |   5381221|  18146605|  15027159|  15747182|  13040124|  11028662|
11466894|   9495576|   7863124|   7608722
   Pumped H |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
 VARIABLE COSTS
  (d) Fuel Costs
   Old T    |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   LC       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   CC       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   CT       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   SC       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
  (e) Unserved Energy
   Un En    |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
  (f) Water Costs
   New H    |   1117959|   3768147|   3114171|   3204950|   2648719|   2214182|
2056601|   1699671|   1404686|   1257222
   Old H    |    295165|    370213|    305961|    252861|    208976|    172707|
142733|    117961|     97489|     80569
  (g) Variable O&M
   Old T    |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   LC       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
```

```
   CC       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   CT       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   SC       |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   New H    |    447184|   1507259|   1245668|   1281980|   1059487|    885673|
822641|    679868|    561875|    502889
   Old H    |   1530155|   3368332|   2783745|   2300616|   1901335|   1571352|
1298638|   1073254|    886987|    733047
   Old PH   |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   New PH   |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
 Total      |  49854720| 171521696| 142238910| 154458385| 128357900| 108288487|
107948099|  89504381|  74313230|  71032989

 TOTAL COST FOR HORIZON =   1097518797.33

 MWh Exp    |         0| -1.390E+8| -1.180E+8| -1.324E+8| -1.077E+8| -90029080|
-89194483| -68830190| -47461827| -35755580
 MWh Imp    |         0|   4564381|   3871633|   2545050|   5928946|   4650564|
6822736|   5468244|   4433953|   1809196

 Res Exp    |         0|         0|  -2532407|  -5342327| -14080739| -15142577|
-19285183| -14544205| -14286438| -16200466
 Res Imp    |         0|         0|         1|         5|   1312681|   3499817|
2899971|   2875357|   4183296|   4483752

 Total      |  49854720|  37092205|  25564444|  19250395|  13784986|  11267212|
9191140|  14473588|  21182214|  25369891

 TOTAL COST FOR HORIZON WITH REVENUE AND PAYMENTS =    227030793.94
```

# GHANA

| **Ghana** – *Received Dec14, 2000* | | | |
|---|---|---|---|
| ***Station Name*** | ***MW*** | ***Station Type*** | ***Station Code #*** |
| TAPCOtakoradi-1 | 330.0 | PGO | Gha Stat1 |
| TICOtakoradi-2 | 220.0 | PGO | Gha Stat2 |
| TICOtakoradi-3 | 330.0 | PGNCC | Gha Stat1 |
| TEMA | 1980.0 | PGNCC | Gha Stat2 |
| Akosombo | 912.0 | H | Gha Stat1 |
| Kpong | 160.0 | H | Gha Stat2 |
| Bui | 400.0 | HN | Gha Stat1 |
| Juale | 87.0 | HN | Gha Stat2 |
| Pwalugu | 48.0 | HN | Gha Stat3 |
| Hemang | 93.0 | HN | Gha Stat4 |



Total Cost = $16521699833.97

## Ghana COST FOR HORIZON = 656894313.95

This Run has 10 Periods. Each Period = 2 years

Program Execution Date 04/26/01
Solver Status = NORMAL COMPLETION
Model Status = OPTIMAL SOLUTION FOUND

A) CHOSEN PROJECTS

Const. Cost is the Construction Cost in Undiscounted Dollars

COMBINED CYCLE PROJECTS

| Period | Country | Station | Capacity Added | Const. Cost |
|---|---|---|---|---|
| per4 | Gha | NS1 | 37 MW | $ 1.36E+7 |
| per5 | Gha | NS1 | 207 MW | $ 7.53E+7 |
| per6 | Gha | NS1 | 85 MW | $ 3.10E+7 |

NEW HYDRO PROJECTS

| Period | Country | Station | Capacity Added | Const. Cost |
|---|---|---|---|---|
| per1 | Gha | newh1 | 115 MW | $ 1.39E+8 |
| per1 | Gha | newh4 | 40 MW | $ 6.79E+7 |
| per2 | Gha | newh1 | 0 MW | $ 2.77E+5 |
| per2 | Gha | newh4 | 0 MW | $ 1.36E+5 |
| per3 | Gha | newh1 | 0 MW | $ 2.77E+5 |
| per3 | Gha | newh4 | 0 MW | $ 1.36E+5 |
| per4 | Gha | newh1 | 0 MW | $ 2.77E+5 |
| per4 | Gha | newh4 | 0 MW | $ 1.36E+5 |
| per5 | Gha | newh1 | 0 MW | $ 2.77E+5 |
| per5 | Gha | newh4 | 0 MW | $ 1.36E+5 |
| per6 | Gha | newh1 | 0 MW | $ 2.77E+5 |
| per6 | Gha | newh4 | 0 MW | $ 1.36E+5 |
| per7 | Gha | newh1 | 0 MW | $ 2.77E+5 |
| per7 | Gha | newh4 | 0 MW | $ 1.36E+5 |
| per8 | Gha | newh1 | 0 MW | $ 2.77E+5 |
| per8 | Gha | newh4 | 0 MW | $ 1.36E+5 |
| per9 | Gha | newh1 | 0 MW | $ 2.77E+5 |
| per9 | Gha | newh4 | 0 MW | $ 1.36E+5 |
| per10 | Gha | newh1 | 0 MW | $ 2.77E+5 |
| per10 | Gha | newh4 | 0 MW | $ 1.36E+5 |

OLD HYDRO EXPANSION

| Period | Country | Station | Capacity Added | Const. Cost |
|---|---|---|---|---|
| per4 | Gha | Stat1 | 106 MW | $ 7.76E+7 |
| per5 | Gha | Stat1 | 10 MW | $ 7.19E+6 |
| per6 | Gha | Stat1 | 34 MW | $ 2.47E+7 |

OLD TRANSMISSION EXPANSION

| Period | Between | Capacity Added |
|---|---|---|
| per2 | Gha and ICo | 112 MW |
| per2 | Gha and Tog | 342 MW |
| per3 | Gha and ICo | 216 MW |
| per4 | Gha and ICo | 40 MW |
| per7 | Gha and Tog | 163 MW |
| per8 | Gha and Tog | 365 MW |
| per9 | Gha and Tog | 458 MW |
| per10 | Gha and ICo | 246 MW |
| per10 | Gha and Tog | 727 MW |

B) RESERVES

(Generation Reserve + Firm Import Reserve - Firm Exports = Peak Demand)

| Year | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 | 2018 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| (a) PEAK DEMAND (MW) (From input files) | 1231 | 1383 | 1583 | 1746 | 1924 | 2122 | 2339 | 2579 | 2843 | 3135 |
| (b) PEAK LOAD CARRYING CAPABILITY (MW) (Adjusted by Decay Rate & Reserve Margin) | | | | | | | | | | |
| Combined Cycle | 0 | 0 | 0 | 31 | 206 | 277 | 276 | 276 | 275 | 275 |
| Old Thermal | 461 | 460 | 459 | 459 | 458 | 457 | 456 | 455 | 454 | 453 |

```
  Old Hydro          |     973 |     971 |     969 |    1063 |    1070 |    1099 |
1097 |    1094 |    1092 |    1090
  New Hydro          |     140 |     140 |     140 |     140 |     140 |     140 |
140 |     140 |     140 |     140
 Total               |    1574 |    1571 |    1569 |    1694 |    1874 |    1973 |
1969 |    1965 |    1962 |    1958

(c)   FIRM IMPORT RESERVE (MW)
 (Adjusted by line loss, forced outage rate)
 Imports From:
  Ivory Coast        |       0 |     394 |     585 |     611 |     599 |     522 |
295 |       0 |       0 |       0
  Togo               |       0 |       0 |       0 |       0 |       0 |       0 |
75 |     614 |    1262 |    2002
 Total               |       0 |     394 |     585 |     611 |     599 |     522 |
370 |     614 |    1262 |    2002

(d)   FIRM EXPORTS (MW)
 (Unadjusted)
 Exports to:
  Ivory Coast        |       0 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |     381 |     825
  Togo               |      25 |     582 |     571 |     559 |     548 |     373 |
0 |       0 |       0 |       0
 Total               |      25 |     582 |     571 |     559 |     548 |     373 |
0 |       0 |     381 |     825

(f)   TOTAL RESERVE CAPACITY (MW)
       [ (b) + (c) - (d) = (e) ]
                     |    1549 |    1383 |    1583 |    1746 |    1924 |    2122 |
2339 |    2579 |    2843 |    3135

(g)   TOTAL RESERVE MARGIN  (%)
 [(b)(Adjusted only by decay)+(c)(Adjusted only by line loss)-(d)-(a)]/[(a)-
(c)+(d)]=(f)
  Total              |    41.2%|    12.6%|    12.6%|    12.6%|    13.2%|    13.3%|
13.3%|    13.3%|    13.3%|    13.3%

(i)   AUTONOMY FACTOR   [Generation Reserve(adjusted for FOR, Decay) / Peak
Demand]
 Actual             |  1.396  |  1.240  |  1.081  |  1.059  |  1.071  |  1.025  |
0.928  |  0.840  |  0.761  |  0.689
 Required           |  0.500  |  0.500  |  0.500  |  0.500  |  0.500  |  0.500  |
0.500  |  0.500  |  0.500  |  0.500


(j)   MAXIMUM IMPORTS (MW)
 [Maximum hourly flow of energy during the year unadjusted]
 Imports from:
  Ivory Coast        |     286 |      57 |       0 |       0 |       0 |       0 |
0 |       0 |       0 |       0
  Togo               |       0 |     363 |     354 |     399 |     389 |     464 |
638 |     960 |    1361 |    2002

(j)   MAXIMUM IMPORTS (MW)
 [Time period from which the maximum import flow come from]
 Maximum Import time:
```

| FRM | YEAR | SEASON | DAY | HOUR | MW |
|---|---|---|---|---|---|
| ICo | per1 | summer | offpeak | hr9 | 286.5 |
| ICo | per2 | summer | offpeak | avdy | 56.8 |
| Tog | per2 | winter | offpeak | hr9 | 362.6 |
| Tog | per3 | summer | offpeak | hr9 | 354.1 |
| Tog | per4 | winter | offpeak | hr9 | 399.1 |
| Tog | per5 | winter | offpeak | hr9 | 388.6 |
| Tog | per6 | winter | offpeak | hr9 | 464.0 |
| Tog | per7 | summer | offpeak | hr9 | 637.7 |
| Tog | per7 | summer | offpeak | avnt | 637.7 |
| Tog | per7 | summer | offpeak | avdy | 637.7 |
| Tog | per7 | winter | offpeak | hr9 | 637.7 |
| Tog | per7 | winter | offpeak | avnt | 637.7 |
| Tog | per7 | winter | offpeak | avdy | 637.7 |
| Tog | per8 | summer | offpeak | hr9 | 959.9 |
| Tog | per8 | summer | offpeak | avnt | 959.9 |
| Tog | per8 | summer | offpeak | avdy | 959.9 |
| Tog | per8 | winter | offpeak | hr9 | 959.9 |
| Tog | per8 | winter | offpeak | avnt | 959.9 |
| Tog | per8 | winter | offpeak | avdy | 959.9 |
| Tog | per9 | summer | offpeak | hr9 | 1361.3 |
| Tog | per9 | summer | offpeak | avnt | 1361.3 |
| Tog | per9 | summer | offpeak | avdy | 1361.3 |
| Tog | per9 | summer | peak | avnt | 1361.3 |
| Tog | per9 | summer | average | avnt | 1361.3 |
| Tog | per9 | winter | offpeak | hr9 | 1361.3 |
| Tog | per9 | winter | offpeak | avnt | 1361.3 |
| Tog | per9 | winter | offpeak | avdy | 1361.3 |
| Tog | per9 | winter | peak | avnt | 1361.3 |
| Tog | per9 | winter | average | avnt | 1361.3 |
| Tog | per10 | summer | offpeak | hr19 | 2001.6 |
| Tog | per10 | summer | offpeak | hr20 | 2001.6 |
| Tog | per10 | summer | offpeak | hr21 | 2001.6 |
| Tog | per10 | summer | peak | hr19 | 2001.6 |
| Tog | per10 | summer | peak | hr20 | 2001.6 |
| Tog | per10 | summer | peak | hr21 | 2001.6 |
| Tog | per10 | summer | average | hr19 | 2001.6 |
| Tog | per10 | summer | average | hr20 | 2001.6 |
| Tog | per10 | summer | average | hr21 | 2001.6 |
| Tog | per10 | winter | offpeak | hr19 | 2001.6 |
| Tog | per10 | winter | offpeak | hr20 | 2001.6 |
| Tog | per10 | winter | offpeak | hr21 | 2001.6 |
| Tog | per10 | winter | peak | hr19 | 2001.6 |
| Tog | per10 | winter | peak | hr20 | 2001.6 |
| Tog | per10 | winter | peak | hr21 | 2001.6 |
| Tog | per10 | winter | average | hr19 | 2001.6 |
| Tog | per10 | winter | average | hr20 | 2001.6 |
| Tog | per10 | winter | average | hr21 | 2001.6 |

(k) MAXIMUM EXPORTS (MW)
[Maximum hourly flow of energy during the year unadjusted]
Exports to:

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ivory Coast | 0 | 73 | 225 | 187 | 306 | 294 | 332 | 478 | 593 | 825 | |

```
  Togo              |      92 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |       0 |       0

(j)   MAXIMUM EXPORTS (MW)
 [Time period from which the maximum export flow come from]
 Maximum Export time:
   TO |  YEAR | SEASON |   DAY   | HOUR |     MW

  ICo | per2  | winter | peak    | hr20 |     72.7
  ICo | per3  | summer | offpeak | hr21 |    225.0
  ICo | per4  | summer | peak    | hr21 |    186.5
  ICo | per5  | summer | offpeak | hr20 |    306.4
  ICo | per6  | winter | offpeak | hr21 |    294.1
  ICo | per7  | summer | offpeak | hr21 |    332.4
  ICo | per8  | summer | offpeak | avnt |    477.9
  ICo | per9  | summer | offpeak | avnt |    593.0
  ICo | per9  | summer | offpeak | hr19 |    593.0
  ICo | per9  | summer | offpeak | hr20 |    593.0
  ICo | per9  | summer | offpeak | hr21 |    593.0
  ICo | per9  | summer | peak    | hr9  |    593.0
  ICo | per9  | summer | peak    | avdy |    593.0
  ICo | per9  | summer | average | hr9  |    593.0
  ICo | per9  | winter | offpeak | hr19 |    593.0
  ICo | per9  | winter | offpeak | hr20 |    593.0
  ICo | per9  | winter | peak    | avnt |    593.0
  ICo | per9  | winter | peak    | avdy |    593.0
  ICo | per9  | winter | average | hr9  |    593.0
  ICo | per9  | winter | average | avnt |    593.0
  ICo | per9  | winter | average | avdy |    593.0
  ICo | per10 | summer | peak    | hr9  |    825.0
  ICo | per10 | summer | peak    | hr20 |    825.0
  ICo | per10 | summer | peak    | hr21 |    825.0
  ICo | per10 | summer | average | hr21 |    825.0
  ICo | per10 | winter | peak    | hr20 |    825.0
  ICo | per10 | winter | peak    | hr21 |    825.0
  ICo | per10 | winter | average | hr21 |    825.0
  Tog | per1  | summer | peak    | hr19 |     91.6


======================================================================


         C)   INCREMENTAL AND CUMULATIVE GENERATION CAPACITY
======================================================================


(a)   GENERATION CAPACITY (MW)   [Unadjusted]
 Incremental
  Combined Cycle   |       0 |       0 |       0 |      37 |     207 |      85 |
0 |       0 |       0 |       0
  New Hydro        |     154 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |       0 |       0
  Old Hydro        |       0 |       0 |       0 |     106 |      10 |      34 |
0 |       0 |       0 |       0
```

(b) GENERATION CAPACITY (MW) [Unadjusted]
Cumulative
Old Thermal | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550 | 550
Combined Cycle | 0 | 0 | 0 | 37 | 245 | 330 | 330 | 330 | 330 | 330
New Hydro | 154 | 155 | 155 | 155 | 156 | 156 | 156 | 157 | 157 | 157
Old Hydro | 1072 | 1072 | 1072 | 1178 | 1188 | 1222 | 1222 | 1222 | 1222 | 1222

(e) OLD TRANSMISSION CAPACITY (MW) [Unadjusted]
Incremental
Ivory Coast | 0 | 112 | 216 | 40 | 0 | 0 | 0 | 0 | 0 | 246
Togo | 0 | 342 | 0 | 0 | 0 | 0 | 163 | 365 | 458 | 727

(f) OLD TRANSMISSION CAPACITY (MW) [Unadjusted]
Cumulative
Ivory Coast | 327 | 439 | 655 | 695 | 695 | 695 | 695 | 695 | 695 | 941
Togo | 256 | 598 | 598 | 598 | 598 | 598 | 761 | 1126 | 1584 | 2310

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## D) DEMAND/SUPPLY

==========

(Energy Demand + Energy Exported + Energy Dumped = Energy Generation + Energy Imported + Energy Unserved)

---

(a) ENERGY DEMAND (MWh/Year) [Yearly Total]
Local Demand | 7332217 | 8314562 | 9432234 | 1.06E+7 | 1.17E+7 | 1.29E+7 | 1.42E+7 | 1.57E+7 | 1.73E+7 | 1.90E+7
Exports | 621912 | 85598 | 808618 | 519353 | 1158840 | 1362735 | 1626719 | 2981239 | 4849462 | 6239375
Total | 7954128 | 8400160 | 1.02E+7 | 1.11E+7 | 1.28E+7 | 1.42E+7 | 1.58E+7 | 1.86E+7 | 2.21E+7 | 2.53E+7

(b) ENERGY SUPPLY (MWh/Year) [Yearly Total]
Combined Cycle | 0 | 0 | 0 | 328220 | 2142524 | 2885861 | 2880092 | 2874335 | 2795258 | 2170689
Old Thermal | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 | 0
Old Hydro | 6137000 | 6137000 | 6137000 | 6137000 | 6137000 | 6137000 | 6137000 | 6137000 | 6137000 | 6137000
New Hydro | 1298900 | 1298900 | 1298900 | 1298900 | 1298900 | 1298900 | 1298900 | 1298900 | 1298900 | 1298900
Imports | 518228 | 964260 | 2804952 | 3348469 | 3259459 | 3917119 | 5506676 | 8322038 | 1.19E+7 | 1.57E+7

```
 Total             | 7954128 | 8400160 | 1.02E+7 | 1.11E+7 | 1.28E+7 | 1.42E+7 |
1.58E+7 | 1.86E+7 | 2.21E+7 | 2.53E+7

(c)   SUPPLY, BY STATION TYPE

Combined Cycle Generation (MWh)   [Yearly, by Station]
 Station:
  NS1              |       0 |       0 |       0 |  328220 | 2142524 | 2885861 |
2880092 | 2874335 | 2795258 | 2170689
 Total             |       0 |       0 |       0 |  328220 | 2142524 | 2885861 |
2880092 | 2874335 | 2795258 | 2170689

Combined Cycle Load Factor   [Yearly, by Station]
 Station:
  NS1              |    0.00 |    0.00 |    0.00 |  100.00 |  100.00 |  100.00 |
100.00 |  100.00 |   97.44 |   75.82

Old Thermal Generation (MWh)   [Yearly, by Station]
 Station:
  Stat1            |       0 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |      13 |       0
  Stat2            |       0 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |       0 |       0
 Total             |       0 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |      13 |       0

Old Thermal Load Factor   [Yearly, by Station]
 Station:
  Stat1            |    0.00 |    0.00 |    0.00 |    0.00 |    0.00 |    0.00 |
0.00 |    0.00 |    0.00 |    0.00
  Stat2            |    0.00 |    0.00 |    0.00 |    0.00 |    0.00 |    0.00 |
0.00 |    0.00 |    0.00 |    0.00

Old Hydro Generation (MWh)   [Yearly, by Station]
 Station:
  Stat1            | 5100000 | 5100000 | 5100000 | 5100000 | 5100000 | 5100000 |
5100000 | 5100000 | 5100000 | 5100000
  Stat2            | 1037000 | 1037000 | 1037000 | 1037000 | 1037000 | 1037000 |
1037000 | 1037000 | 1037000 | 1037000
 Total             | 6137000 | 6137000 | 6137000 | 6137000 | 6137000 | 6137000 |
6137000 | 6137000 | 6137000 | 6137000

Old Hydro Load Factor   [Yearly, by Station]
 Station:
  Stat1            |   63.96 |   64.09 |   64.22 |   57.59 |   57.14 |   55.41 |
55.52 |   55.63 |   55.75 |   55.86
  Stat2            |   74.14 |   74.28 |   74.43 |   74.58 |   74.73 |   74.88 |
75.03 |   75.18 |   75.33 |   75.48

New Hydro Generation (MWh)   [Yearly, by Station]
 Station:
  newh1            |  962900 |  962900 |  962900 |  962900 |  962900 |  962900 |
962900 |  962900 |  962900 |  962900
  newh4            |  336000 |  336000 |  336000 |  336000 |  336000 |  336000 |
336000 |  336000 |  336000 |  336000
 Total             | 1298900 | 1298900 | 1298900 | 1298900 | 1298900 | 1298900 |
1298900 | 1298900 | 1298900 | 1298900
```

```
New Hydro Load Factor   [Yearly, by Station]
 Station:
  newh1            |   96.00 |   96.00 |   96.00 |   96.00 |   96.00 |   96.00 |
96.00 |   96.00 |   96.00 |   96.00
  newh4            |   96.00 |   96.00 |   96.00 |   96.00 |   96.00 |   96.00 |
96.00 |   96.00 |   96.00 |   96.00

(D)   ENERGY IMPORTED (MWh/Year)
 Imported From:
  Ivory Coast      |  518228 |   97557 |       0 |       0 |       0 |       0 |
0 |       0 |       0 |       0
  Togo             |       0 |  866703 | 2804952 | 3348469 | 3259459 | 3917119 |
5506676 | 8322038 | 1.19E+7 | 1.57E+7
 Total             |  518228 |  964260 | 2804952 | 3348469 | 3259459 | 3917119 |
5506676 | 8322038 | 1.19E+7 | 1.57E+7

(e)   ENERGY EXPORTED (MWh/Year)
 Exported To:
  Ivory Coast      |       0 |   85598 |  808618 |  519353 | 1158840 | 1362735 |
1626719 | 2981239 | 4849462 | 6239375
  Togo             |  621912 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |       0 |       0
 Total             |  621912 |   85598 |  808618 |  519353 | 1158840 | 1362735 |
1626719 | 2981239 | 4849462 | 6239375

==========================================================================


                    E)   COST & REVENUES
==========================================================================


(a)   FUEL COSTS ($/Year)
 Undiscounted
  Old Thermal      |       0 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |     610 |       0
  Combined Cycle   |       0 |       0 |       0 | 8550957 | 5.58E+7 | 7.52E+7 |
7.50E+7 | 7.49E+7 | 7.28E+7 | 5.66E+7

 Total Discounted Fuel Cost for Horizon = $235099129

FUEL COSTS ($/MWh)   [Yearly fuel costs/yearly MWh generation]
 Undiscounted
  Old Thermal      |    UNDF |    UNDF |    UNDF |    UNDF |    UNDF |    UNDF |
UNDF |    UNDF |   45.78 |    UNDF
  Combined Cycle   |    UNDF |    UNDF |    UNDF |   26.05 |   26.05 |   26.05 |
26.05 |   26.05 |   26.05 |   26.05

(b)   O & M COSTS ($/Year)
 Undiscounted
  Combined Cycle   |       0 |       0 |       0 |  755655 | 4932698 | 6644080 |
6630812 | 6617570 | 6435693 | 4999184
  Old Thermal      |       0 |       0 |       0 |       0 |       0 |       0 |
0 |       0 |      31 |       0
```

```
  Old Hydro        | 1227400 | 1227400 | 1227400 | 1227400 | 1227400 | 1227400 |
1227400 | 1227400 | 1227400 | 1227400
  New Hydro        | 1320503 | 1322623 | 1324744 | 1326864 | 1328984 | 1331105 |
1333225 | 1335345 | 1337466 | 1339586

 Total Discounted O & M Cost for Horizon = $43523802

(c)   WATER COSTS ($/Year)
 Undiscounted
  Old Hydro        | 3068500 | 3068500 | 3068500 | 3068500 | 3068500 | 3068500 |
3068500 | 3068500 | 3068500 | 3068500
  New Hydro        |  649450 |  649450 |  649450 |  649450 |  649450 |  649450 |
649450 |  649450 |  649450 |  649450

 Total Discounted Water Cost for Horizon = $33110138


(d)   CAPITAL COSTS

 levelized(t) = (construction cost)(crf) in all t following construction

Year   |    2002 |    2004 |    2006 |    2008 |    2010 |    2012 |    2014 |
2016 |    2018 |    2020 |    Total


                      COMBINE CYCLE STATIONS
Station            Undiscounted Levelized Dollars
 NS1   |      0  |      0  |      0  | 2.4E+6  | 1.6E+7  | 2.1E+7  | 2.1E+7  |
2.1E+7  | 2.1E+7  | 2.1E+7  | 1.3E+8
Station            Discounted Levelized Dollars
 NS1   |      0  |      0  |      0  | 1.2E+6  | 6.7E+6  | 7.5E+6  | 6.2E+6  |
5.1E+6  | 4.2E+6  | 3.5E+6  | 3.4E+7

 Total Discounted Cost for Horizon = $68828053


                      NEW HYDRO STATIONS
Station            Undiscounted Levelized Dollars
 newh1 | 1.7E+7  | 1.7E+7  | 1.7E+7  | 1.7E+7  | 1.7E+7  | 1.7E+7  | 1.7E+7  |
1.7E+7  | 1.7E+7  | 1.7E+7  | 1.7E+8
 newh4 | 6.8E+6  | 6.9E+6  | 6.9E+6  | 6.9E+6  | 6.9E+6  | 6.9E+6  | 6.9E+6  |
6.9E+6  | 7.0E+6  | 7.0E+6  | 6.9E+7
Station            Discounted Levelized Dollars
 newh1 | 1.5E+7  | 1.3E+7  | 1.0E+7  | 8.6E+6  | 7.1E+6  | 5.9E+6  | 4.9E+6  |
4.0E+6  | 3.3E+6  | 2.8E+6  | 7.5E+7
 newh4 | 6.2E+6  | 5.1E+6  | 4.3E+6  | 3.5E+6  | 2.9E+6  | 2.4E+6  | 2.0E+6  |
1.7E+6  | 1.4E+6  | 1.1E+6  | 3.1E+7

 Total Discounted Cost for Horizon = $210808614

                      OLD HYDRO STATION EXPANSIONS
Station            Undiscounted Levelized Dollars
 Stat1 |      0  |      0  |      0  | 6.6E+6  | 7.2E+6  | 9.3E+6  | 9.3E+6  |
9.3E+6  | 9.3E+6  | 9.3E+6  | 6.0E+7
Station            Discounted Levelized Dollars
 Stat1 |      0  |      0  |      0  | 3.4E+6  | 3.1E+6  | 3.3E+6  | 2.7E+6  |
2.2E+6  | 1.8E+6  | 1.5E+6  | 1.8E+7
```

```
 Total Discounted Cost for Horizon = $35923626

                       OLD TRANS. EXPANSIONS
Station            Undiscounted Levelized Dollars
 ICo   |      0  | 525510  | 1.5E+6  | 1.7E+6  | 1.7E+6  | 1.7E+6  | 1.7E+6  |
1.7E+6  | 1.7E+6  | 2.9E+6  | 1.5E+7
 Tog   |      0  | 1.7E+6  | 1.7E+6  | 1.7E+6  | 1.7E+6  | 1.7E+6  | 2.6E+6  |
4.4E+6  | 6.8E+6  | 1.0E+7  | 3.3E+7
Station            Discounted Levelized Dollars
 ICo   |      0  | 394226  | 954268  | 885866  | 732120  | 605058  | 500048  |
413263  | 341540  | 470782  | 5.3E+6
 Tog   |      0  | 1.3E+6  | 1.1E+6  | 895305  | 739921  | 611505  | 746163  |
1.1E+6  | 1.3E+6  | 1.7E+6  | 9.5E+6

 Total Discounted Cost for Horizon = $14800476

=========================================================================


                   F)   GAINS FROM TRADE
=========================================================================


Year         |    2002  |    2004  |    2006  |    2008  |    2010  |    2012  |
2014  |    2016  |    2018  |    2020
REVENUE FROM EXPORTS
 EXPORTED TO:
  Ivory Coas|         0|   3263126|  25582544|  14492738|  26725737|  27571509|
28341584|  42885087|  51354267|  49176526
  Togo      |  39911122|         0|         0|         0|         0|         0|
0|         0|         0|         0

PAYMENTS FOR IMPORTS
 IMPORTED FROM:
  Ivory Coas|  33436629|   3719015|         0|         0|         0|         0|
0|         0|         0|         0
  Togo      |         0|  32862829|  88118435|  92921889|  74758859|  78800545|
93433044| 116606802| 122111005| 121340820



REVENUE FROM RESERVES
 EXPORTED TO:
  Ivory Coas|         0|         0|         0|         0|         0|         0|
0|         0|  18284061|  40146488
  Togo      |         2|  13817048|  27332394|  36610123|  29896946|  16953909|
0|         0|         0|         0

PAYMENTS FOR RESERVES
 IMPORTED FROM:
  Ivory Coas|         0|   3005161|  14225690|  28776749|  32228267|  23852649|
15887232|         0|         0|         0
  Togo      |         0|         0|         0|         0|         0|         0|
4044538|  27160195|  60307700|  92032796
```

| Year | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 | 2018 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| Average Buying Price Present Value | 32.26 | 18.97 | 15.71 | 13.88 | 11.47 | 10.06 | 8.48 | 7.01 | 5.14 | 3.88 |
| Average Selling Price Present Value | 34.61 | 20.45 | 16.97 | 14.97 | 12.37 | 10.85 | 9.35 | 7.72 | 5.68 | 4.23 |
| Average Buying Price Real Dollars | 35.54 | 25.29 | 25.34 | 27.08 | 27.08 | 28.74 | 29.33 | 29.31 | 26.03 | 23.74 |
| Average Selling Price Real Dollars | 38.13 | 27.26 | 27.38 | 29.22 | 29.22 | 31.02 | 32.32 | 32.29 | 28.76 | 25.90 |

| Year | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 | 2018 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| Average Buying Price Present Value | 0 | 3816 | 12150 | 23545 | 26905 | 22852 | 26929 | 22135 | 23892 | 22990 |
| Average Selling Price Present Value | 0 | 12799 | 25833 | 35305 | 29416 | 24520 | 0 | 0 | 25774 | 26106 |
| Average Buying Price Real Dollars | 0 | 5087 | 19598 | 45953 | 63537 | 65299 | 93107 | 92604 | 120945 | 140818 |
| Average Selling Price Real Dollars | 0 | 17062 | 41668 | 68903 | 69467 | 70064 | 0 | 0 | 130469 | 159906 |

==========

## G) OBJECTIVE FUNCTION BREAKDOWN (Present Value)

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| Year | 2002 | 2004 | 2006 | 2008 | 2010 | 2012 | 2014 | 2016 | 2018 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|
| FIXED COSTS | | | | | | | | | | |
| (a) Capital Costs | | | | | | | | | | |
| OT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| LC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CC | 0 | 0 | 0 | 2485260 | 13411592 | 14950454 | 12355747 | 10211361 | 8439142 | 6974497 |
| CT | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SC | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Old H | 0 | 0 | 0 | 6757330 | 6101823 | 6514576 | 5383947 | 4449543 | 3677309 | 3039098 |

```
   New H     |  42716970|  35373852|  29292912|  24257219|  20087124|  16633851|
13774193|  11406117|   9445126|   7821248
   Pumped H  |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   New Line  |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   Old Line  |         0|   3410085|   4075174|   3562341|   2944084|   2433127|
2492422|   2950882|   3363416|   4369422
  (b) Unserved MegaWatts
   UM        |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
  (c) Fixed O&M
   LC        |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   CC        |         0|         0|         0|       768|      4144|      4620|
3818|      3155|      2608|      2155
   CT        |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   SC        |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   New H     |   1925670|   1594644|   1320517|   1093509|    905522|    749850|
620937|    514185|    425784|    352580
   Pumped H  |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
 VARIABLE COSTS
  (d) Fuel Costs
   Old T     |         0|         0|         0|         0|         0|         0|
0|         0|       241|         0
   LC        |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   CC        |         0|         0|         0|   8762713|  47273112|  52623360|
43403443|  35798909|  28771928|  18465423
   CT        |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   SC        |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
  (e) Unserved Energy
   Un En     |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
  (f) Water Costs
   New H     |   1179032|    974407|    805295|    665533|    550027|    454568|
375676|    310476|    256592|    212059
   Old H     |   5570653|   4603846|   3804831|   3144488|   2598751|   2147728|
1774982|   1466927|   1212336|   1001931
  (g) Variable O&M
   Old T     |         0|         0|         0|         0|         0|         0|
0|         0|        12|         0
   LC        |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   CC        |         0|         0|         0|    773600|   4173419|   4645756|
3831792|   3160440|   2540076|   1630186
   CT        |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   SC        |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   New H     |    471613|    389763|    322118|    266213|    220011|    181827|
150270|    124190|    102637|     84824
```

```
   Old H     |   2228261|   1841538|   1521932|   1257795|   1039500|    859091|
709993|    586771|    484935|    400772
   Old PH    |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
   New PH    |         0|         0|         0|         0|         0|         0|
0|         0|         0|         0
 Total       |  54092200|  48188135|  41142779|  53026770|  99309110| 102198808|
84877221|  70982957|  58722140|  44354195

 TOTAL COST FOR HORIZON =    656894313.95

 MWh Exp     | -39911122|  -3263126| -25582544| -14492738| -26725737| -27571509|
-28341584| -42885087| -51354267| -49176526
 MWh Imp     |  33436629|  36581844|  88118435|  92921889|  74758859|  78800545|
93433044| 116606802| 122111005| 121340820

 Res Exp     |        -2| -13817048| -27332394| -36610123| -29896946| -16953909|
0|         0| -18284061| -40146488
 Res Imp     |         0|   3005161|  14225690|  28776749|  32228267|  23852649|
19931770|  27160195|  60307700|  92032796

 Total       |  47617706|  70694966|  90571966| 123622547| 149673554| 160326585|
169900451| 171864866| 171502518| 168404797

 TOTAL COST FOR HORIZON WITH REVENUE AND PAYMENTS =   1324179955.79
```